# Part 2: Assessment on Special Areas of Conservation

## Report to Inform Appropriate Assessment (RIAA)

2024

| Version | Purpose of Document | Authored by | Reviewed by | Approved by |
|---|---|---|---|---|
| FINAL | Final | RPS | RPS | RPS |

| Approval for Issue | | |
|---|---|---|
| For and on behalf of Ossian OWFL | Rich Morris | 12 June 2024 |

| | |
|---|---|
| Prepared by: | **RPS** |
| Prepared for: | **Ossian Offshore Wind Farm Limited (OWFL)** |
| | |
| Checked by: | **David Still** |
| Accepted by: | **Fraser Malcolm** |
| Approved by: | **Rich Morris** |

# CONTENTS


1. Introduction ....1
   1.1. The Purpose of this Report to Inform Appropriate Assessment ....1
   1.2. Structure of the RIAA ....1
   1.3. Structure of this Document ....1
2. Consultation ....1
3. Summary of HRA Stage One LSE Screening Conclusions for Special Areas of Conservation ....7
   3.1. Screening Outcomes for the Array Alone ....7
      3.1.1. Annex II Diadromous Fish ....7
      3.1.2. Annex II Marine Mammals ....7
   3.2. Screening Outcomes for the Array In-Combination with other Plans and Projects ....7
      3.2.1. Annex II Diadromous Fish ....7
      3.2.2. Annex II Marine Mammals ....8
4. Information To Support the Appropriate Assessment ....11
   4.1. Introduction ....11
   4.2. Maximum Design Scenarios ....11
   4.3. Designed in Measures ....11
   4.4. Baseline Information ....11
   4.5. Conservation Objectives and Conservation Advice ....11
   4.6. Approach to the In-Combination Assessment ....11
5. Assessment of Potential Adverse Effects on Integrity: Annex II Diadromous Fish ....12
   5.1. Introduction ....12
   5.2. Baseline ....13
      5.2.1. River Dee SAC ....13
      5.2.2. River South Esk SAC ....15
      5.2.3. Tweed Estuary SAC ....16
      5.2.4. River Tweed SAC ....17
      5.2.5. River Tay SAC ....18
      5.2.6. River Spey SAC ....19
      5.2.7. Berriedale and Langwell Waters SAC ....20
      5.2.8. River Teith SAC ....21
      5.2.9. River Oykel SAC ....21
   5.3. Assessment of the Adverse Efects of the Array Alone ....22
      5.3.1. Underwater Noise Generated during Piling and UXO Clearance ....22
      5.3.2. Effects due to EMFs from Subsea Electrical Cabling ....41
   5.4. Assessment of Adverse Effects of the Array in-Combination with other Plans and Projects ....50
      5.4.1. Plans and Projects Screened into the In-Combination Assessment for Annex II Diadromous Fish ....50
      5.4.2. Underwater Noise Generated during Piling and UXO Clearance ....54
      5.4.3. Effects due to EMFs from Subsea Electrical Cabling ....72
6. Assessment of Potential Adverse Effects on Integrity: Annex II Marine Mammals ....82
   6.1. Introduction ....82
   6.2. Baseline ....83
      6.2.1. Berwickshire and North Northumberland Coast SAC ....83
      6.2.2. Southern North Sea SAC ....84
      6.2.3. Moray Firth SAC ....85
      6.2.4. Reference Populations and Densities ....86
      6.2.5. Marine Mammals and Underwater Noise ....87
   6.3. Assessment of the Adverse Effects of the Array Alone ....92
      6.3.1. Underwater Noise Generated During Piling ....92
      6.3.2. Underwater Noise Generated during UXO Clearance ....107
      6.3.3. Injury and Disturbance due to Site-Investigation Surveys (Including Geophysical Surveys) ....120
      6.3.4. Changes in Prey Availability ....129
      6.3.5. Entanglement ....133
      6.3.6. Injury and Disturbance from Underwater Noise Generated during the Operation of Floating Wind Turbines and Anchor Mooring Lines ....138
   6.4. Assessment of Adverse Effects of the Array in-Combination with other Plans and Projects ....141
      6.4.1. Plans and Projects Screened into the In-Combination Assessment for Annex II MArine Mammals ....141
      6.4.2. Underwater Noise Generated During Piling ....147
      6.4.3. Underwater Noise Generated during UXO Clearance ....160
      6.4.4. Disturbance due to Site-Investigation Surveys (Including Geophysical Surveys) ....168
      6.4.5. Changes in Prey Availability ....173
      6.4.6. Entanglement ....177
      6.4.7. Injury and Disturbance from Underwater Noise Generated during the Operation of Floating Wind Turbines and Anchor Mooring Lines ....180
7. Summary ....182
8. References ....186


# FIGURES


Figure 3.1: Location of all European Sites Designated for Annex II Diadromous Fish and Marine Mammals for which an Appropriate Assessment is Required ....8

Figure 5.1: Location of European Sites Designated for Annex II Diadromous Fish for which an Appropriate Assessment is Required ....13

Figure 5.2: Modelled 10 dB $SPL_{pk}$ Noise Contours for Piling Hammer Energy of 4,400 kJ at the North Location ....28

Figure 5.3: Modelled 10 dB $SPL_{pk}$ Noise Contours for Piling Hammer Energy of 4,400 kJ at the South Location ...29

Figure 5.4: Location of Other Plans and Projects Considered for the In-Combination Effects Assessment on SACs with Annex II Diadromous Fish Features ....51

Figure 6.1: Location of European Sites Designated for Annex II Marine Mammals for which an Appropriate Assessment is Presented....82

Figure 6.2: MUs and SMUs Relevant to the Report to Inform Appropriate Assessment ....87

Figure 6.3: Unweighted $SEL_{ss}$ Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary overlaid with Carter *et al.* (2022) At-sea Density Maps and Berwickshire and North Northumberland Coast SAC ....100

Figure 6.4: Unweighted SELss Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Southern Limit of the Site Boundary overlaid with Carter *et al.* (2022) At-sea Density Maps and Berwickshire and North Northumberland SAC....101

Figure 6.5: Unweighted 140 and 160 dB re 1 µPa ($SPL_{rms}$) Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary overlaid with Carter *et al.* (2022) At-sea Density Maps....101

Figure 6.6: Unweighted 140 and 160 dB re 1 µPa ($SPL_{rms}$) Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Southern Limit of the Site Boundary overlaid with Carter *et al.* (2022) At-sea Density Maps....102

Figure 6.7: Unweighted $SEL_{ss}$ Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary and 26 km EDR ....104

Figure 6.8: Unweighted $SEL_{ss}$ Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Southern Limit of the Site Boundary and 26 km EDR ....104

Figure 6.9: Unweighted $SEL_{ss}$ Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary....106

Figure 6.10: Unweighted $SPL_{rms}$ Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary....107

Figure 6.11: High Order UXO Clearance Mitigation Flow Chart for the Array ([1]Assuming UXO is not Suitable for Low Order Techniques) ....114

Figure 6.12: EDR of 26 km for harbour porpoise of the Southern North Sea SAC in relation to UXO Clearance (based on JNCC (2020) ....118

Figure 6.13: Location of Other Plans and Projects Considered for the In-Combination Effects Assessment on SACs with Annex II Marine Mammals Features....142

Figure 6.14: Maximum Spatial Overlap of Underwater Noise Impacts upon the Southern North Sea SAC from In-Combination Piling with the Array and Relevant Plans and Projects Based on the Maximum 26 km EDR Approach....157

Figure 6.15: Maximum Spatial Overlap of Underwater Noise Impacts upon the Southern North Sea SAC from In-Combination UXO Clearance with the Array and Relevant Plans and Projects Based on the 26 km EDR Approach....166

# 1. INTRODUCTION

## 1.1. THE PURPOSE OF THIS REPORT TO INFORM APPROPRIATE ASSESSMENT

1. This Report to Inform Appropriate Assessment (RIAA) has been prepared by RPS and Niras on behalf of Ossian Offshore Wind Limited (Ossian OFWL) (hereafter referred to as the 'Applicant'). The purpose of this RIAA is to support the Habitats Regulations Appraisal (HRA) of the Array in the determination of the implications for European sites. This RIAA builds upon the Array HRA Stage One Likely Significant Effects (LSE[2]) Screening Report (Part 1, appendix 1A) and the subsequent joint Environmental Impact Assessment (EIA) Scoping and LSE[1] Screening advice received in the Ossian Array Scoping Opinion (Marine Directorate – Licensing Operations Team (MD-LOT) (2023)).

2. This RIAA assesses whether the Array could have an adverse effect, either alone, or in-combination with other plans or projects, on the integrity of any European site. This report will provide the Competent Authority with the information required to undertake an HRA Stage Two Appropriate Assessment.

3. The scope of this RIAA Part 2 SAC Assessments covers all relevant SACs and qualifying interest features where a LSE[2] has been identified in the Array HRA Stage One LSE[2] Screening Report (Part 1, appendix 1A), due to the potential impacts arising from the Array. This includes 'offshore' European sites and features.

4. There were no SACs designated for Annex I habitats or Annex II European otter *Lutra lutra* advanced to the RIAA stage, and therefore these are not included in this assessment.

## 1.2. STRUCTURE OF THE RIAA

5. As detailed in section 1.5 of Part 1, for clarity and ease of navigation, the RIAA is structured and reported in the below 'Parts', as follows:

- Executive Summary and Conclusion;
- Part 1: Introduction;
- Part 2 Special Area of Conservation (SAC) Assessments; and
- Part 3: Special Protection Area (SPA) and Ramsar Site Assessments.

## 1.3. STRUCTURE OF THIS DOCUMENT

6. As stated in paragraph 5, this document constitutes Part 2 of the RIAA, and presents the assessment of the implications of the Array on SACs.

7. This document is structured as follows:

- Section 1: Introduction, which details the purpose and structure of the RIAA and this Part 2 document;
- Section 2: Consultation, which provides a summary of relevant consultation undertaken to date, the responses provided, and how these have been addressed in this Part of the RIAA;
- Section 3: Summary of the HRA Stage One LSE[2] Screening conclusions for SACs;
- Section 4: Information to inform the Appropriate Assessment, which includes the Maximum Design Scenario (MDS), information on designed in measures, and an outline of the baseline data on the SACs;
- Section 5: Assessment of adverse effects on integrity on designated sites for Annex II diadromous fish both alone and in-combination with other plans and projects;
- Section 6: Assessment of adverse effects on integrity on designated sites for Annex II marine mammals both alone and in-combination with other plans and projects;
- Section 7: Overall summary of this Part of the RIAA; and
- Section 8: References.

# 2. CONSULTATION

8. Consultation has been undertaken with statutory stakeholders with regards to the relevant Annex I habitats and Annex II diadromous fish and marine mammal features of SACs. A summary of all relevant consultation undertaken to date is presented in Table 2.1.

**Table 2.1: Summary of Key Consultations on Relevant to Part 2 of the RIAA**

| Date | Receptor Group | Consultee | Type of Consultation | Summary of Consultation | Change Required to Screening Outcomes? | Where Addressed in this Document |
|---|---|---|---|---|---|---|
| November 2022 | Annex I habitats | Marine Directorate – Science, Evidence, Data and Digital (MD-SEDD) (formerly MSS), Marine Directorate - Licensing Operations Team (MD-LOT), NatureScot | Pre scoping workshop | The list of designated sites with benthic subtidal ecology features in the vicinity of the Array was presented. The distance between the site boundary and the closest European site designated for Annex I habitats was noted (Berwickshire and North Northumberland Coast SAC: 113.95 km). It was assumed that Annex I features of this site would not be screened into the RIAA as a result. The stakeholders did not raise concerns to this approach. | No | Paragraph 2. |
| November 2022 | Annex II diadromous fish | MD-SEDD, MD-LOT, NatureScot | Pre scoping workshop | The approach to the LSE$^2$ Screening was presented to stakeholders. SACs to be considered were proposed, and agreement was sought for a 100 km buffer around the site boundary to screen in SACs with Annex II diadromous fish features. MSS advised that the River Spey SAC (181.56 km away) and other SACs that flow into the Moray Firth should be considered, as there is potential for diadromous fish to migrate along the east coast of Scotland. | Yes, the changes suggested in this consultation were implemented in the Array HRA Stage One LSE$^2$ Screening Report, and the SACs flowing into the Moray Firth were included. | All SACs that have been considered for Annex II diadromous fish are presented in Table 3.1 and assessed for the Array alone and in-combination with other plans and projects in section 5. |
| November 2022 | Annex II marine mammals | MD-SEDD, MD-LOT, NatureScot | Pre scoping workshop | Approach to the LSE$^2$ Screening for marine mammals was presented to stakeholders. It was noted that the LSE$^2$ Screening was to be based upon Management Units (MUs) for harbour porpoise *Phocoena phocoena,* bottlenose dolphin *Tursiops truncatus* (east coast sites only), grey seal *Halichoerus grypus,* and harbour seal *Phoca vitulina,* Foraging ranges for seals was to be used to inform the LSE Screening buffer (100 km for grey seal and 50 km for harbour seal as a precaution). NatureScot noted that 50 km for harbour seal and 20 km for grey seal were appropriate for SACs in Scotland as these are classed as breeding sites. | No, as stated within the Array HRA Stage One LSE$^2$ Screening Report, precautionary 100 km buffers were adopted for both seal species based on telemetry data and preliminary results from site-specific aerial surveys | All SACs that have been considered for Annex II marine mammals are presented in Table 3.1 and assessed for the Array alone and in-combination with other plans and projects in section 6. |
| June 2023 | Annex I habitats | NatureScot | Scoping opinion | *"We agree with the conclusion in the HRA Stage One LSE Screening Report that no sites with Annex I habitat features need to be taken forward to assessment."* | No | Paragraph 2. |
| June 2023 | Annex II diadromous fish | NatureScot | Scoping opinion | *"We note that several SACs for migratory fish are included in this list of designated sites. As previously advised to Marine Directorate, we cannot advise on these species under the HRA process. Due to uncertainty on where migratory fish (Atlantic salmon, sea lamprey, and river lamprey) go within marine waters and any connectivity back to natal rivers, we consider these species should be assessed through EIA only and not through HRA."* | No | The advice provided by NatureScot and MD-LOT has been acknowledged, however, Annex II diadromous fish have been retained for assessment within this RIAA. A high level assessment is provided in section 5, taking account of the uncertainty in relation to connectivity between diadromous fish and natal rivers. It should also be noted that the latest available evidence was considered within this RIAA.<br><br>As stated in the Array HRA Stage One LSE$^2$ Screening Report, river lamprey *Lampetra fluviatilis* were not considered as the marine phase of their life cycle is restricted to the coastal/estuarine environment. Given the distance of the site boundary offshore (approximately 80 km from the nearest coastline), interactions between river lamprey and activities associated with the Array are not anticipated. |
| June 2023 | Annex II diadromous fish | NatureScot | Scoping opinion | *"For diadromous fish species, we do not have population data for any salmon or lamprey SAC data forms. This inability to understand connectivity between individual rivers and the development area currently prohibits an informed assessment of the actual impact on individual site integrity. We are aware of work being led by ScotMER on the Review of Evidence of Diadromous Fish, which is an area of research that may change conclusions on how diadromous fish are treated in both EIA and HRA going forward."* | No | |
| June 2023 | Annex II diadromous fish | MD-LOT | Scoping opinion | *"With regards to the HRA Stage One LSE Screening Report, the Scottish Ministers agree with the advice within the NatureScot representation that migratory fish should currently be assessed through the EIA process and not through the HRA process. However, the Developer should engage with the Scottish Ministers and NatureScot in regard to any change in how diadromous fish should be assessed through EIA and HRA as a result of ongoing research in this area."* | No | |

| Date | Receptor Group | Consultee | Type of Consultation | Summary of Consultation | Change Required to Screening Outcomes? | Where Addressed in this Document |
|---|---|---|---|---|---|---|
| June 2023 | Annex II marine mammals | NatureScot | Scoping opinion | *"We note that HRA Stage One LSE Screening Report paragraph 157 lists five United Kingdom (UK) European sites designated for Annex II marine mammals. However, due to the distance between the proposal and these designated sites, alongside the foraging ranges of the relevant species, we do not support this list of UK European sites. We advise that Moray Firth SAC should remain scoped into assessment, and all other marine mammal sites should be scoped out. We offer further advice below. In the absence of noise contours and until noise modelling is complete, Moray Firth SAC should be scoped in for further assessment, due to the potential connectivity of the coastal bottlenose dolphin population on the East coast of Scotland and the Moray Firth SAC."* | Yes. The Moray Firth SAC for bottlenose dolphin was intially screened out at the Array HRA Stage One LSE[2] Screening Report. However, following the advice from NatureScot, this SAC was screened in for further assessment until noise modelling was completed. Whilst there was no direct overlap of noise modelling contours with the Moray Firth SAC, there was overlap of mild disturbance with the Coastal East Scotland MU for bottlenose dolphin. Since there is a possibility that individuals from the Moray Firth SAC may travel along the coast within the Coastal East Scotland MU, this SAC was screened back in and taken forward for further assessment in the RIAA.<br><br>Further, the Isle of May SAC (designated for grey seal) was screened in during the Array HRA Stage One LSE[2] Screening Report but has not been taken forward for Appropriate Assessment based | All SACs that have been considered for Annex II marine mammals are presented in Table 3.1 and assessed for the Array alone and in-combination with other plans and projects in section 6. |
| June 2023 | Annex II marine mammals | NatureScot | Scoping opinion | *"Our position is that the Southern North Sea SAC can be screened out for harbour porpoise, due to the distance from the proposal."* | | |
| June 2023 | Annex II marine mammals | NatureScot | Scoping opinion | *"Grey seal telemetry data is presented in Figure 5.1* [of the HRA Stage One LSE[2] Screening Report]*. We note that there is evidence of grey seal travelling through the proposed array site, however we are content for grey seal SACs to be scoped out at this time as there is no evidence of hotspots or regular foraging areas within the project boundary".* | | |
| June 2023 | Annex II marine mammals | Natural England | Scoping opinion | *"It is Natural England's conclusion that a potential impact pathway exists between the proposed Array and the Berwickshire and North Northumberland Coast SAC for grey seals. The SAC straddles Scottish and English waters. The Farne Islands, in English waters, supports the largest grey seal colony in the SAC."* | | |
| June 2023 | Annex II marine mammals | Natural England | Scoping opinion | *"The Southern North Sea SAC lies wholly in English waters. It is Natural England's conclusion that a potential impact pathway exists between the proposed Array and the Southern North Sea SAC for harbour porpoise."* | | |
| June 2023 | Annex II marine mammals | Natural England | Scoping opinion | *"Natural England cannot agree with the advice provided by NatureScot with regard to scoping the Berwickshire and North Northumberland Coast SAC and the Southern North Sea SAC out of the HRA Stage 1 LSE Screening Report. It is therefore our advice that these SACs are retained at the screening stage and taken forward to Appropriate Assessment".* | | |

| Date | Receptor Group | Consultee | Type of Consultation | Summary of Consultation | Change Required to Screening Outcomes? | Where Addressed in this Document |
|---|---|---|---|---|---|---|
| June 2023 | Annex II marine mammals | MD-LOT | Scoping opinion | *"In regard to the HRA Stage One LSE Screening Report, in line with the NatureScot representation, the Scottish Ministers advise the Moray Firth SAC should remain screened into the assessment in respect of bottlenose dolphin until noise modelling is completed, after which the Developer should engage with NatureScot to agree an approach to assessment. The Berwickshire and North Northumberland Coast SAC for grey seal and Southern North Sea SAC for harbour porpoise should also remain screened in for further assessment in line with the Natural England advice dated 05 June 2023* [see row above] *(unless later agreed with Natural England that these can be screened out). The remaining UK protected sites and associated marine mammal qualifying features should be scoped out of the assessment."* | on the NatureScot and MD-LOT consultation provided in these rows and following an assessment of potential connectivity using the seal haul out and telemetry study (Stevens, 2023). Using the telemetry data, potential connectivity between the site boundary and the Isle of May SAC was assessed as low, further supporting MD-LOT and NatureScot's position to screen this SAC out.<br><br>The Firth of Tay and Eden Estuary (designated for harbour seal) was screened out in the Array HRA Stage One LSE[2] Screening Report, and this remains unchanged and has not been carried forward for Appropriate Assessment.<br><br>Following advice from Natural England, the Berwickshire and North Northumberland Coast SAC (designated for grey seal) was retained at the LSE[2] Screening Stage, and brought forward to the RIAA.<br><br>Finally, the Southern North Sea SAC remains screened in as per the Array HRA Stage One LSE[2] Screening Report, and has been carried forward for Appropriate Assessment. | |

| Date | Receptor Group | Consultee | Type of Consultation | Summary of Consultation | Change Required to Screening Outcomes? | Where Addressed in this Document |
|---|---|---|---|---|---|---|
| June 2023 | Annex I habitats and Annex II diadromous fish | NatureScot | Scoping opinion | *"Wet storage could represent a very significant impact pathway with respect to floating wind. It is unclear from the scoping report if there are any plans for wet storage of assembled and/ or component parts of floating turbines in the construction, and operation and maintenance phases, and what this would entail, or potential locations identified. Consideration of wet storage, including potential impacts on receptors, needs to be addressed with the forthcoming EIA Report and HRA."* | No | Should wet storage occur within the footprint of the site boundary, then potential impacts would include 'temporary habitat loss and disturbance' to benthic habitats and fish and 'changes in prey availability' in relation to marine mammals. However, there are no SACs designated for Annex I habitats within the site boundary and SACs designated for Annex I habitats were screened out during the HRA Stage One LSE[2] Screening and therefore have not been taken forward to the RIAA. There are no SACs designated for Annex II diadromous fish within the site boundary and the only impacts on diadromous fish taken forward to the RIAA were 'underwater noise generated by piling and UXO clearance' and 'effects due to EMFs from subsea electrical cabling'. For Annex II marine mammals, the impact 'changes in prey availability' was only screened in during the Stage One LSE[2] Screening in relation to 'underwater noise generated by piling and UXO clearance'. Therefore there are no impact pathways between the potential impacts from wet storage and any SACs qualifying features which could result in any adverse effect on integrity of any SACs in this Part of the RIAA. |
| January 2024 | Annex II marine mammals | NatureScot | Response on Marine Mammal Consultation Note 1 | Marine Mammal Consultation Note 1 established the designated sites taken forward to the assessment in the EIA and HRA. NatureScot were content with the approach for the inclusion of Moray Firth SAC and deferred to advice from Natural England on Berwickshire and North Northumberland Coast SAC and Southern North Sea SAC. | No | All SACs that have been considered for Annex II marine mammals are presented in Table 3.1 and assessed for the Array alone and in-combination with other plans and projects in section 6. |

| Date | Receptor Group | Consultee | Type of Consultation | Summary of Consultation | Change Required to Screening Outcomes? | Where Addressed in this Document |
|---|---|---|---|---|---|---|
| March 2024 | Annex II marine mammals | NatureScot | Response on Marine Mammal Consultation Note 2 | NatureScot advised that pre-piling mitigation should be based on the instantaneous risk for PTS onset, but the impact assessment itself should use Cumulative Sound Exposure Level ($SEL_{cum}$) (acknowledging all the caveats around it being over-precautionary due to the assumptions made) as well as Peak Sound Pressure Level ($SPL_{pk}$) (i.e. the dual metric approach). If the $SEL_{cum}$ predictions indicate that there may be auditory injury to marine mammals, then the figures for injury should be inputted to the Interim Population Consequences of Disturbance (iPCoD) model. | No | Following more recent advice from NatureScot following Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E of the Array EIA Report), the assessment of PTS from piling and Unexploded Ordnance (UXO) is based upon the dual metric approach, whereby the maximum injury range from either $SPL_{pk}$ or $SEL_{cum}$ is used in assessment and inputted into the iPCoD modelling for piling (see volume 2, chapter 10 of the Array EIA Report). This dual metric approach aligns with the approach presented in the Array Scoping Report. |
| March 2024 | Annex II marine mammals | NatureScot | Response on Marine Mammal Consultation Note 2 | NatureScot confirmed the approach to base auditory injury assessment on the number of animals remaining present following 30 minutes of Acoustic Deterrent Device (ADD) usage is appropriate for population modelling (iPCoD). NatureScot stated they expected the use of ADDs to be secured via conditions of any relevant consents. | No | The assessment of auditory injury for piling is based upon inclusion of 30 minute ADD duration and is presented in volume 2, chapter 10 of the Array EIA Report. This is also applied to the population modelling which informs the assessment (use of iPCoD, as presented in the Array Scoping Report), with a detailed iPCoD report presented in Volume 3, appendix 10.3 of the Array EIA Report. |

# 3. SUMMARY OF HRA STAGE ONE LSE SCREENING CONCLUSIONS FOR SPECIAL AREAS OF CONSERVATION

9. This section summarises all pathways for potential LSE[2] on Annex II diadromous fish and marine mammal features of SACs (arising alone or in-combination with other plans and projects).

## 3.1. SCREENING OUTCOMES FOR THE ARRAY ALONE

10. The potential for LSE[2] as a result of the Array alone has been identified following the HRA Stage One LSE[2] Screening with respect to 12 SACs (Figure 3.1 and Table 3.1).

11. There were no SACs designated for Annex I habitats or Annex II European otter advanced to the RIAA stage.

### 3.1.1. ANNEX II DIADROMOUS FISH

12. Nine SACs designated for Annex II diadromous fish and dependent features were advanced to the RIAA. These are as follows (presented in increasing distance from the closest point on the site boundary):

- River Dee SAC;
- River South Esk SAC;
- Tweed Estuary SAC;
- River Tweed SAC;
- River Tay SAC;
- River Spey SAC;
- Berriedale and Langwell Waters SAC;
- River Teith SAC; and
- River Oykel SAC

13. Standard data forms for all SACs are available from the JNCC (2024c).

14. A summary of these nine SACs for which LSE[2] was identified for Annex II diadromous fish features, alongside corresponding impact pathways for each phase of the Array, are presented in Table 3.1. No updates relating to Annex II diadromous fish have been made to the HRA Stage One LSE[2] Screening outcomes.

15. Some of the nine SACs advanced to the RIAA are also designated for Annex II river lamprey, however, as stated in the Array HRA Stage One LSE[2] Screening Report, this species was not considered as the marine phase of their life cycle is restricted to the coastal/estuarine environment. Given the distance of the site boundary offshore (approximately 80 km from the nearest coastline), interactions between river lamprey and activities associated with the Array are not anticipated.

16. Some of the SACs are also designated for Annex II freshwater pearl mussel *Margaritifera margaritifera,* which will not be directly affected by the Array as it is restricted to freshwater environments but has the potential to be indirectly impacted due to its symbiotic life cycle with Atlantic salmon *Salmo salar*. The freshwater pearl mussel relies on Atlantic salmon, the host species during a critical parasitic phase of its life cycle, where its larvae attach to the gills of Atlantic salmon in mid to late summer and drop off in spring (Taeubert *et al.*, 2017). Therefore, there could be an indirect effect upon the freshwater pearl mussel feature of European sites, should the Atlantic salmon population be adversely affected by the Array.

### 3.1.2. ANNEX II MARINE MAMMALS

17. Three SACs designated for Annex II marine mammals were advanced to the RIAA. These are as follows (presented in increasing distance from the closest point on the site boundary):

- Berwickshire and North Northumberland Coast SAC;
- Southern North Sea SAC; and
- Moray Firth SAC.

18. Standard data forms for all SACs are available from the JNCC (2024c).

19. A summary of the three SACs for which LSE[2] was identified for Annex II marine mammal features, alongside corresponding impact pathways for each phase of the Array, are presented in Table 3.1.

20. Since the Array EIA Scoping Report (Ossian OWFL, 2023) and Array HRA Stage One LSE[2] Screening Report (Part 1, appendix 1A) were published, there have been some minor changes to the impacts associated with marine mammals. Firstly, the impact of ‘Operational noise from anchor mooring lines’ was assessed as such in the Array HRA Stage One LSE[2] Screening Report. This has since been updated to ‘Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines’ and has been assessed accordingly in this Part of the RIAA and in the Array EIA Report (Ossian OWFL, 2024). Secondly, the potential impact of injury and disturbance due to site-investigation surveys (including geophysical surveys), has since been included in the Array EIA Report, and has been carried forward for assessment in this Part of the RIAA. At the time of writing the Array HRA Stage One LSE[2] Screening Report, site-investigation survey activities (including geophysical) were to be submitted in a separate application (Part 1, appendix 1A). Any potential impacts as a result of site-investigation (including geophysical) survey activities were therefore out with the scope of the Array HRA Stage One LSE[2] Screening Report. They have since been included as part of the Application, and therefore, the potential impact of ‘injury and disturbance due to site-investigation surveys (including geophysical surveys)’ has been considered as a potential impact at the HRA Stage Two Appropriate Assessment in the construction and operation and maintenance phases, as per the approach taken in the Array EIA Report.

21. Following a comprehensive assessment of potential connectivity as well as feedback from NatureScot, Natural England and MD-LOT provided as part of the Ossian Array Scoping Opinion and LSE[2] Screening feedback (Table 2.1), the Isle of May SAC, which is designated for grey seal, has not been carried forward for Appropriate Assessment. This deviates from the Array HRA Stage One LSE[2] Screening Report, wherein the potential for LSE[2] on this SAC was proposed.

22. No other updates relating to Annex II marine mammals have been made to the HRA Stage One LSE[2] Screening outcomes.

## 3.2. SCREENING OUTCOMES FOR THE ARRAY IN-COMBINATION WITH OTHER PLANS AND PROJECTS

### 3.2.1. ANNEX II DIADROMOUS FISH

23. A precautionary approach to the selection of relevant European sites for Annex II diadromous fish was adopted in the Array HRA Stage One LSE[2] Screening Report. This involved the use of a large buffer of 100 km and screening in all SACs which flowed into the Firth of Forth and the Moray Firth (Part 1, appendix 1A). Due to this approach, all SACs relevant for Appropriate Assessment, particularly due to the potential for disruption to migration (i.e. barriers to migration) to/from natal rivers, have been identified. Therefore, there is no potential for connectivity between the site boundary and Annex II diadromous fish from any additional SACs beyond those identified as relevant in the Array HRA Stage One LSE[2] Screening Report.

24. This screening approach was adopted for both Atlantic salmon (and freshwater pearl mussel by proxy) and sea lamprey *Petromyzon marinus*, however with the caveat that there is little information on their spatial

distribution of sea lamprey out with rivers and estuaries. Therefore, the screening approach was highly precautionary for sea lamprey.

25. No potential impact pathways were identified between the Array and any additional sites designated for Annex II diadromous fish. Therefore, there is no potential for in-combination effects at any sites apart from those which are screened in for HRA Stage Two Appropriate Assessment (i.e. those listed in paragraph 12).

### 3.2.2. ANNEX II MARINE MAMMALS

26. A precautionary approach to selection of relevant European sites for Annex II marine mammals was adopted in the Array HRA Stage One LSE[2] Screening Report (Part 1, appendix 1A). Marine mammals are highly mobile animals with the potential to forage over wide areas. Therefore, all European sites for marine mammal features with a range that overlaps with the site boundary were considered. The screening area extended to the relevant marine mammal MUs and Seal Management Units (SMU) for each species, as defined by the Inter Agency Marine Mammal Working Group (IAMMWG) for cetaceans (IAMMWG, 2022, 2023), and by the Special Committee on Seals (SCOS) for grey seal (SCOS, 2023). For grey seal, the site boundary is located within the East Scotland Seal SMU, borders the Northeast England Seal SMU, and is within the vicinity of the Moray Firth Seal SMU. Thus, any European sites that are located within the East Scotland Seal MU were considered, and a precautionary buffer of 100 km was used to identify SACs within the adjacent SMUs which had the potential for connectivity with the Array.

27. There were 19 transboundary sites identified within the search areas outlined above. However, all relevant impact pathways were considered extremely weak, given the distance between the site boundary and the sites (from 246 to 687 km depending on the site) (Part 1, appendix 1A). As a result, only negligible effects would be apparent and could not contribute, in any material way, to an in-combination effect. As such, LSE[2] associated with planned projects or other activities in the vicinity of the site boundary are also not anticipated for marine mammal features of any transboundary site.

28. No potential impact pathways were identified between the Array and any additional sites designated for Annex II marine mammals. Therefore, there is no potential for in-combination effects at any sites apart from those which are screened in for HRA Stage Two Appropriate Assessment (i.e. those listed in paragraph 17).

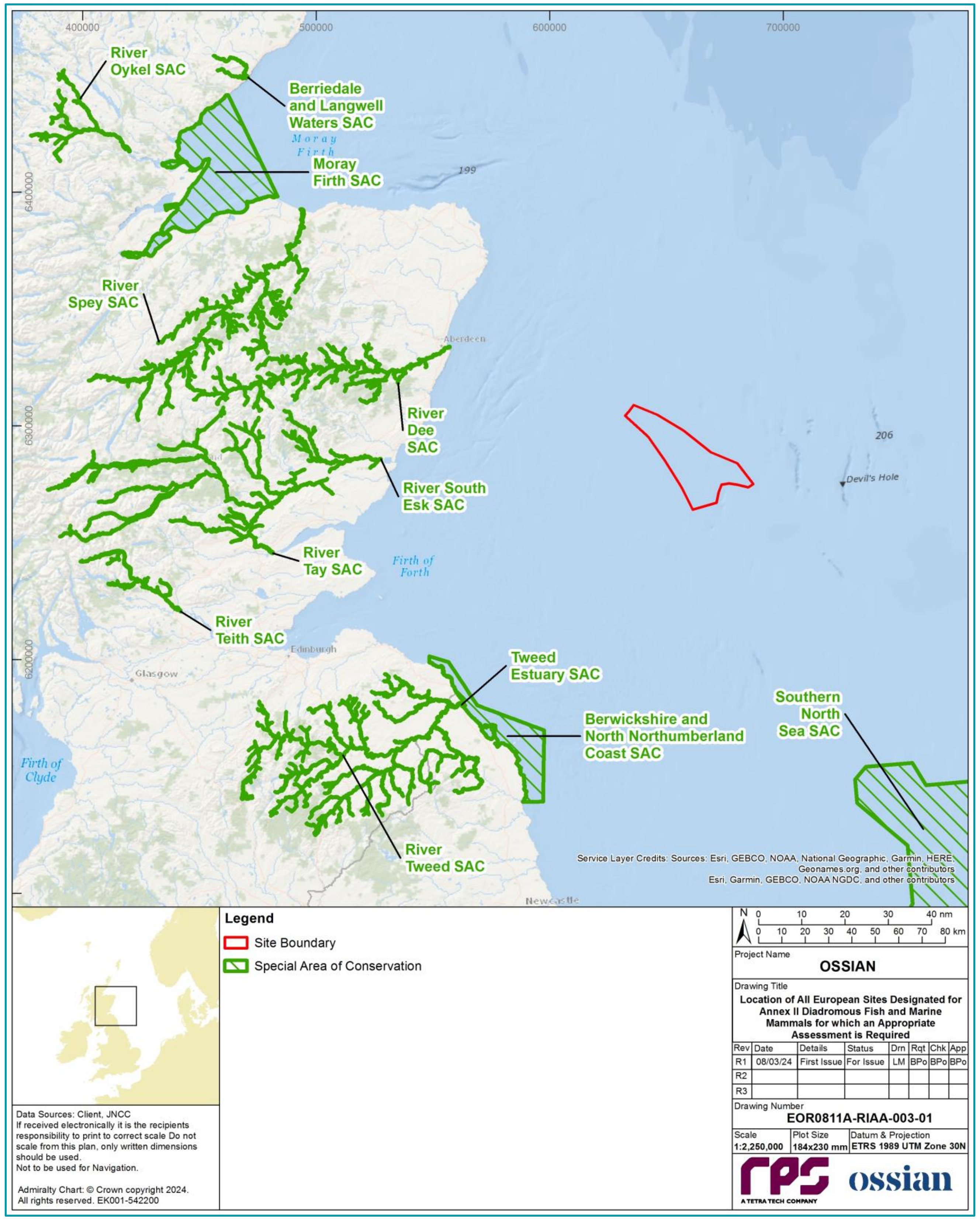


**Figure 3.1: Location of all European Sites Designated for Annex II Diadromous Fish and Marine Mammals for which an Appropriate Assessment is Required**

**Table 3.1: Summary of all SACs for which the Potential for LSE[2] could not be Discounted, and for Which Information to Support an Appropriate Assessment is Presented**

| Site ID | Site Name | Distance to Site Boundary (km) | Relevant Qualifying Features | Potential Impact | Project Phase C | Project Phase O | Project Phase D |
|---|---|---|---|---|---|---|---|
| **Annex II Diadromous Fish** | | | | | | | |
| UK0030251 | River Dee SAC | 80.57 | Atlantic salmon and freshwater pearl mussel | Underwater noise generated during piling and UXO clearance | ✓ | - | - |
| | | | | Effects due to EMFs from subsea electrical cabling | - | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| UK0030262 | River South Esk SAC | 107.13 | Atlantic salmon and freshwater pearl mussel | Underwater noise generated during piling and UXO clearance | ✓ | - | - |
| | | | | Effects due to EMFs from subsea electrical cabling | - | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| UK0030292 | Tweed Estuary SAC | 128.65 | Sea lamprey | Underwater noise generated during piling and UXO clearance | ✓ | - | - |
| | | | | Effects due to EMFs from subsea electrical cabling | - | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| UK0012691 | River Tweed SAC | 133.40 | Atlantic salmon and sea lamprey | Underwater noise generated during piling and UXO clearance | ✓ | - | - |
| | | | | Effects due to EMFs from subsea electrical cabling | - | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| UK0030312 | River Tay SAC | 162.32 | Atlantic salmon and sea lamprey | Underwater noise generated during piling and UXO clearance | ✓ | - | - |
| | | | | Effects due to EMFs from subsea electrical cabling | | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| UK0019811 | River Spey SAC | 181.56 | Atlantic salmon, freshwater pearl mussel, and sea lamprey | Underwater noise generated during piling and UXO clearance | ✓ | - | - |
| | | | | Effects due to EMFs from subsea electrical cabling | - | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| UK0030088 | Berriedale and Langwell Waters SAC | 219.57 | Atlantic salmon | Underwater noise generated during piling and UXO clearance | ✓ | - | - |
| | | | | Effects due to EMFs from subsea electrical cabling | - | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| UK0030263 | River Teith SAC | 244.19 | Atlantic salmon and sea lamprey | Underwater noise generated during piling and UXO clearance | ✓ | | - |
| | | | | Effects due to EMFs from subsea electrical cabling | | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| UK0030261 | River Oykel SAC | 259.33 | Atlantic salmon and freshwater pearl mussel | Underwater noise generated during piling and UXO clearance | ✓ | - | - |
| | | | | Effects due to EMFs from subsea electrical cabling | - | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| **Annex II Marine Mammals** | | | | | | | |
| UK0017072 | Berwickshire and North Northumberland Coast SAC | 113.95 | Grey seal | Underwater noise generated during piling | ✓ | - | - |
| | | | | Underwater noise generated during UXO clearance | ✓ | - | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| | | | | Changes in prey availability | ✓ | | - |
| | | | | Entanglement | - | ✓ | - |
| | | | | Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines | - | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |

| Site ID | Site Name | Distance to Site Boundary (km) | Relevant Qualifying Features | Potential Impact | Project Phase | | |
|---|---|---|---|---|---|---|---|
| | | | | | C | O | D |
| UK0030311 | Southern North Sea SAC | 129.86 | Harbour porpoise | Underwater noise generated during piling | ✓ | - | - |
| | | | | Underwater noise generated during UXO clearance | ✓ | - | - |
| | | | | Injury and disturbance due to site-investigation surveys (including geophysical surveys) | ✓ | ✓ | - |
| | | | | Changes in prey availability | ✓ | - | - |
| | | | | Entanglement | - | ✓ | - |
| | | | | Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines | - | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |
| UK0019808 | Moray Firth SAC | 175.86 | Bottlenose dolphin | Underwater noise generated during piling | ✓ | - | - |
| | | | | Underwater noise generated during UXO clearance | ✓ | - | - |
| | | | | Injury and disturbance due to site-investigation surveys (including geophysical surveys) | ✓ | ✓ | - |
| | | | | Changes in prey availability | ✓ | - | - |
| | | | | Entanglement | - | ✓ | - |
| | | | | Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines | - | ✓ | - |
| | | | | In-combination effects | ✓ | ✓ | - |

# 4. INFORMATION TO SUPPORT THE APPROPRIATE ASSESSMENT

## 4.1. INTRODUCTION

29. As described in Part 1 of this RIAA, a European site is progressed to the Appropriate Assessment stage (Stage Two of the HRA process) where it is not possible to exclude an LSE[2] on one or more of its qualifying interest features with regards to the site's conservation objectives. European sites and potential impacts of the Array that require an Appropriate Assessment are therefore those for which LSE[2] could not be ruled out during the HRA Stage One LSE[2] Screening exercise and following consultation.

30. Information to help inform the Appropriate Assessment for SACs is provided in sections 4.2 to 4.6. The information provided includes a description of the SACs under consideration, their qualifying interest features, and an assessment of the implications of the Array for the site in view of the conservation objectives of each site and considering any adverse effect on site integrity. A cross-referencing approach has been adopted to aide readability and reduce repetition where relevant, but this has been carefully carried out to ensure that all information required for a robust HRA of each site is presented.

## 4.2. MAXIMUM DESIGN SCENARIOS

31. All SAC assessment presented in this Part of the RIAA have been based on a realistic Maximum Design Scenario (MDS), which was derived from the Project Design Envelope (PDE). The final design will be no greater than the parameters set out in the MDS, and in some instances, may be less. An overview of the MDS considered for the assessment of potential impacts on Annex II diadromous fish and Annex II marine mammals is presented per potential impact (see sections 5.3 and 6.3 respectively). This MDS is consistent with that used for the fish and shellfish and marine mammal assessments in the Array EIA Report (Ossian OWFL, 2024).

## 4.3. DESIGNED IN MEASURES

32. As part of the project design process, a number of designed in measures have been included in the Array and are committed to be delivered by the Applicant as part of the Array. These designed in measures are integrated into the project description for the Array and are not considered as mitigation measures intended to specifically avoid or reduce effects on European sites.

33. Measures intended specifically to avoid or reduce effects on European sites were not considered during the HRA Stage One LSE[2] Screening exercise but are included within the HRA Stage Two Appropriate Assessment for determination of Adverse Effects on Integrity. Where relevant, this Part of the RIAA indicates whether adverse impacts on European sites are likely and if so, whether those effects can be avoided through the introduction of mitigation measures that avoid or reduce the impact. These measures are referred to as secondary mitigation and may be taken from the relevant chapters of the Array EIA Report (Ossian OWFL, 2024) or, where necessary, may have been developed specifically to comply with HRA requirements. Where the latter is the case, this has been made clear throughout.

## 4.4. BASELINE INFORMATION

34. Baseline information on the SACs identified for further assessment within the HRA Stage Two Appropriate Assessment has been collated through a comprehensive review of existing desktop studies and datasets. Key desktop data sources are presented in sections 5.2 and 6.2 for Annex II diadromous fish and marine mammals, respectively. Further baseline information is presented within the respective topic chapters in the Array EIA Report and accompanying technical reports for fish and shellfish and marine mammals (Ossian OWFL, 2024).

## 4.5. CONSERVATION OBJECTIVES AND CONSERVATION ADVICE

35. The Statutory Nature Conservation Bodies (SNCBs) have produced conservation advice for European sites under their statutory remit. Their conservation advice provides supplementary information on European sites and their features, and although the content provided is similar, the format of the advice provided varies between the different SNCBs.

36. Given the location and scale of the Array, European sites with the potential to be impacted fall under the remit of the Joint Nature Conservation Committee (JNCC), NatureScot, and/or Natural England. For example, the conservation advice for the Berwickshire and North Northumberland Coast SAC was developed jointly by NatureScot and Natural England but is hosted on Natural England's Designated Site System as an interactive Conservation Advice Package (CAP). Further, the CAP for the Southern North Sea SAC has been jointly developed by Natural England and the JNCC but is hosted on JNCC's website in the form of a 'Conservation Objectives and Advice on Operations' document. The Tweed Estuary SAC is under Natural England's remit and therefore conservation advice is hosted on Natural England's Designated Site System. However, the River Tweed SAC is located within the remit of both the Scottish Borders and Northumberland local authorities, and the CAP was produced by NatureScot and is hosted on the NatureScot sitelink system.

37. For those European sites under the statutory remit of NatureScot, CAP documents have been produced for all terrestrial SACs (many of the river SACs screened in for Annex II diadromous are considered terrestrial), while Conservation and Management Advice (CMA) documents cover marine SACs. These documents contain revised and updated conservation objectives for the features of each European site, site-specific clarifications, advice for the conservation objectives to be achieved, and advice on management required to achieve said conservation objectives. At the time of writing, the River Teith SAC was the only site which does not have a CAP, CMA document, or conservation advice documents such as those detailed in paragraph 36.

38. Conservation objectives of European sites set the framework for establishing appropriate conservation measures for each feature and provide a framework against which plans or projects can be assessed. The conservation objectives present the essential elements needed to ensure that the Favourable Conservation Status (FCS) of a qualifying habitat or species is maintained or restored at the site. The integrity of the site will be maintained if all the conservation objectives are met.

39. Within the NatureScot CAPs and CMAs, the conservation objectives comprise overarching objectives (objectives 1 and 2) that apply to all features of the site, and additional objectives (2a, 2b and 2c) that have been written for each feature. Site-specific supplementary advice is provided for each objective.

40. It is recognised in the conservation advice that if any feature of the European site is in unfavourable condition, the integrity of the site is deemed to be compromised and the overarching objective is therefore to restore site integrity. NatureScot guidance, however, states that with the 'new style' conservation objectives it is not expected that plans or projects must include measures that lead to restoration of features (where restore objectives are in place) in order to gain approval from a competent authority. Instead, a plan or project should not prevent site integrity from being able to be restored where necessary. This means that a plan or project should not prevent a feature from being able to be restored. HRAs should, therefore, focus on and consider if the plan or project is likely to undermine the conservation objectives of the site.

## 4.6. APPROACH TO THE IN-COMBINATION ASSESSMENT

41. The approach taken for the assessment of in-combination impacts has been partly informed by the Cumulative Effects Assessment (CEA) carried out for relevant topics in the Array EIA Report (Ossian

OWFL, 2024). The methodology for the in-combination assessment is compliant with HRA guidance and is summarised in the following paragraphs.

42. The in-combination assessment has assessed potential impacts associated with the Array together with other relevant plans, projects and activities. In-combination effects are defined as the combined effect of the Array with the effects from a number of different plans or projects, on the same receptor or resource.

43. The screening undertaken for the CEA in the Array EIA Report has been used to inform the list of projects and plans relevant to the in-combination assessment. This involved a staged process that considered the level of detail available for projects, plans and activities, as well as the potential for interactions on a conceptual, physical and temporal basis. See volume 3, appendix 6.4 of the Array EIA Report for further details on the screening process).

44. The in-combination assessment presents relevant in-combination impacts of projects according to a tiered approach. This approach provides a framework for placing relative weight upon the potential for each project/plan to be included to ultimately be realised, based upon the project/plan's current stage of maturity and certainty in the projects' parameters. All projects/plans screened in via the previously described screening process have been allocated into one of the three Tiers for the in-combination assessment. It is worth noting that data collection is assessed against the source of this data (i.e. data confidence) to verify its accuracy and reliability. Where quantitative assessment has not been practicable, a mix of qualitative and quantitative or wholly qualitative assessment has been undertaken.

45. The tiered approach which has been utilised within the in-combination assessment employs the following tiers:

- Tier 1 assessment – Array with Proposed offshore export cable corridor(s) and Proposed onshore transmission infrastructure and all plans/projects which became operational since baseline characterisation, those under construction, and those with consent and submitted but not yet determined;
- Tier 2 assessment – All plans/projects assessed under Tier 1, plus projects with a Scoping Report; and
- Tier 3 assessment – All plans/projects assessed under Tier 2, which are reasonably foreseeable, plus those projects likely to come forward when an Agreement for Lease (AfL) has been granted.

46. The specific projects scoped into the in-combination assessment for Annex II diadromous fish and Annex II marine mammals are presented in sections 5.4 and 6.4, respectively. There will be no in-combination effects with the Proposed onshore transmission infrastructure for Annex II diadromous fish and marine mammals, as all onshore works are above MHWS. Therefore, there is no receptor-impact pathway, and the Proposed onshore transmission infrastructure component of Ossian has not been considered further within the in-combination assessment. However, the Proposed offshore export cable corridor(s) is included in the Tier 1 assessment, due to a potential receptor impact pathway for both Annex II diadromous fish and marine mammals.

47. To note, whilst the Proposed offshore export cable corridor(s) is in Tier 1 for the in-combination assessment, due to uncertainty in the final grid connection design and location details of the Proposed offshore export cable corridor(s), it was not possible to undertake a full detailed quantitative assessment at the time of writing.

48. All of the potential impacts included for the alone assessment (see Table 3.1) were brought forward to the in-combination assessment. Some of the potential impacts considered within the Array alone assessment are specific to a particular phase of development. The potential for in-combination effects with other plans or projects requires spatial or temporal overlap with the Array during certain phases of development, therefore potential impacts associated with a certain phase have been omitted from further consideration where no plans or projects were identified to have the potential for in-combination effects during that phase.

49. The in-combination assessment for each Tier generally follows the same methodology for each impact as the alone assessment, in order to conclude the potential for an adverse effect of integrity of the SACs.

# 5. ASSESSMENT OF POTENTIAL ADVERSE EFFECTS ON INTEGRITY: ANNEX II DIADROMOUS FISH

## 5.1. INTRODUCTION

50. This section provides background information and an explanation for the approach taken to assess the potential impacts of the Array on European sites designated for Annex II diadromous fish.

51. As stated in section 3.1, the potential for LSE[2] was identified for the Annex II diadromous fish features of nine SACs, which are listed in Table 5.1 and illustrated in Figure 5.1.

**Table 5.1: European Sites Designated for Annex II Diadromous Fish Features for which an Appropriate Assessment is Presented**

| Site | Feature | Period of Potential Impact |
|---|---|---|
| River Dee SAC | • Atlantic salmon; and<br>• freshwater pearl mussel. | Construction and operation and maintenance phases. |
| River South Esk SAC | • Atlantic salmon; and<br>• freshwater pearl mussel. | |
| Tweed Estuary SAC | • Sea lamprey | |
| River Tweed SAC | • Atlantic salmon; and<br>• sea lamprey. | |
| River Tay SAC | • Atlantic salmon; and<br>• sea lamprey. | |
| River Spey SAC | • Atlantic salmon;<br>• freshwater pearl mussel; and<br>• sea lamprey. | |
| Berriedale and Langwell Waters SAC | • Atlantic salmon. | |
| River Teith SAC | • Atlantic salmon; and<br>• sea lamprey. | |
| River Oykel SAC | • Atlantic salmon; and<br>• freshwater pearl mussel. | |

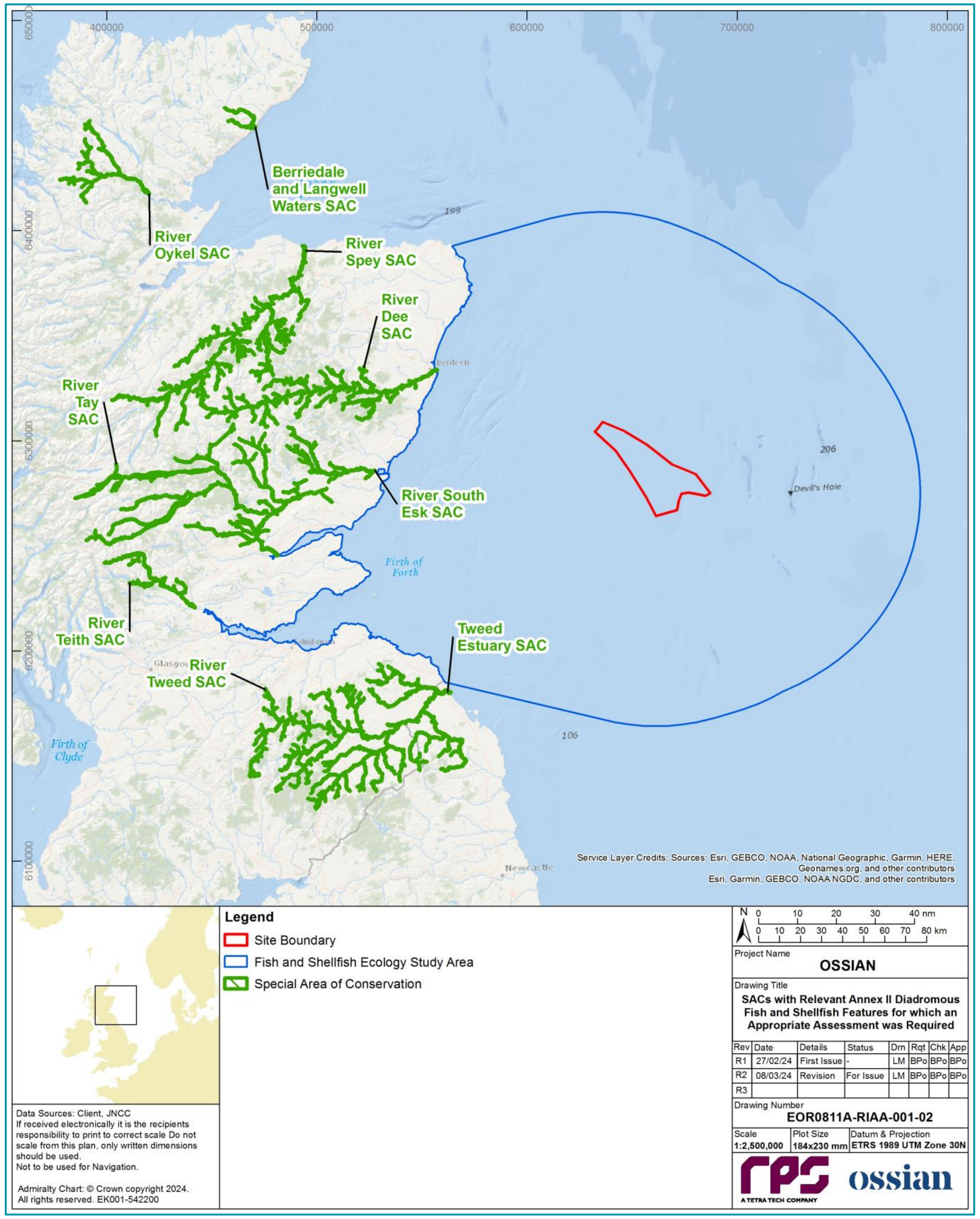


**Figure 5.1: Location of European Sites Designated for Annex II Diadromous Fish for which an Appropriate Assessment is Required**

52. LSE[2]s on the SACs presented in Table 5.1 were identified for the construction and operation and maintenance phases of the Array, and these are outlined in Table 5.3 A range of designed in measures have been committed to as part of the Array, these are presented, where relevant, in section 5.3.

**Table 5.2: Potential For Impact to Annex II Diadromous Fish**

| Project Phase | Potential Impact |
|---|---|
| Construction | Underwater noise generated during piling and UXO clearance |
| Operation and Maintenance | Effects due to EMFs from subsea electrical cabling |

53. The Stage Two Appropriate Assessment (considering effects of the Array both alone and in-combination) for European sites designated for Annex II diadromous fish are presented in section 5.3 and 5.4 respectively. A summary of Assessments undertaken within this Part of the RIAA is provided in section 7.

54. Freshwater pearl mussel has been considered within this section (specifically as a qualifying feature of the River Dee SAC, River South Esk SAC, River Spey SAC, and the River Oykel SAC) because the larval stage of its life cycle is reliant on salmonid species, such as Atlantic salmon (see paragraph 16). The potential for adverse effects to freshwater pearl mussel, if they occur at all, would be indirect and would occur as a result of direct effects on Atlantic salmon, which are a relevant host species for freshwater pearl mussel within the SACs assessed.

## 5.2. BASELINE

55. Baseline information on the relevant screened in Annex II diadromous fish and freshwater pearl mussel features has been gathered through a comprehensive desktop study of existing datasets and materials. Full detail is provided in volume 2, chapter 9 and volume 3, appendix 9.1 of the Array EIA Report (Ossian OWFL, 2024).

56. Within the Array EIA Report, a broad fish and shellfish ecology study area was defined and agreed with SNCBs for the purposes of the baseline characterisation. It encompassed a buffer of 100 km around the site boundary and included the Firth of Forth. A buffer of 100 km was used as it represented a precautionary Zone of Influence (ZoI) of potential impacts due to underwater noise. The fish and shellfish ecology study area provides wider context for the spatially and temporally variable Annex II diadromous fish species and encompasses a potential area in which they may migrate to and from the various SACs assessed in this Part of the RIAA (Figure 5.1). Based on feedback from SNCBs, an additional three SACs in the Moray Firth (and therefore out with the fish and shellfish ecology study area) have been brought forward for Appropriate Assessment (Figure 5.1, see Table 2.1).

### 5.2.1. RIVER DEE SAC

#### Site description

57. At its closest point, the River Dee SAC is located 80.57 km north-west from the site boundary. The entire length of the River Dee is designated as a SAC due to its importance for Atlantic salmon and freshwater pearl mussel. The River Dee originates in the Cairngorms and flows through southern Aberdeenshire to reach the North Sea at Aberdeen. The site covers an area of 2,334.48 ha and is designated for the following Annex II diadromous fish features: Atlantic salmon and freshwater pearl mussel (NatureScot, 2020c).

Feature accounts

Atlantic salmon

58. As a diadromous species, Atlantic salmon live in both freshwater and marine environments throughout their life cycle. Adult Atlantic salmon spawn in the rivers that they were born in (referred to as 'natal rivers') from November to December, and females lay their eggs in gravel depressions known as 'redds'. These are immediately fertilised by a male, and the female will cover the fertilised eggs with gravel (NatureScot, 2023a). The eggs typically hatch in early spring and are known as 'fry' when they reach around 3 cm in length. They develop into 'parr' once they develop markings on their sides, and live in the river for two to three years before migrating to the sea as 'smolts' and 'post-smolts' (NatureScot, 2023a). After one to three years at sea, adult Atlantic salmon migrate back to their natal river to spawn again. Individuals that only spend one year at sea, before migrating back to spawn are referred to as 'grilse', which reach 2 kg to 3 kg in weight (Malcolm *et al.*, 2010, NatureScot, 2023a, Scottish Government, 2019). Individuals that spend two to three years at sea before returning to spawn are referred to as 'multi-sea-winter salmon' and are typically larger than grilse as they've spent more time feeding in marine environments (usually off the coast of Greenland) (Malcolm *et al.*, 2010, NatureScot, 2023a, Scottish Government, 2019). Around 90% to 95% of Atlantic salmon will die after spawning, but those which survive may spawn again (NatureScot, 2023a).

59. Malcolm *et al.* (2015) used metadata to assess the timing of smolt emigration across Scotland. This suggested that most fish leave rivers between mid-April and the end of May. These results do not include the period spent by smolts in the coastal environment after leaving their natal rivers. There was also evidence that smolt emigration is becoming earlier (by around 1.5 days per decade over a period of around 50 years) (Malcolm *et al.*, 2015).

60. Various cues are involved during their return migration to their natal rivers; in earlier phases, sun position and Earth's magnetic field seem to play a role in oceanic orientation (Hansen *et al.*, 1998). Tidal phase and time of day have also been suggested as important factors for their upstream migration (Smith *et al.*, 1997). Migration upstream of estuaries have also been observed to be nocturnal, occurring during ebb tides (Smith *et al.*, 1997). In the final phase of the upstream migration, olfactory cues direct Atlantic salmon up the river (Hasler *et al.*, 1983). For smolts migrating downstream, migratory activity has been identified to be associated with night time while daytime was utilised more for prey detection and predator avoidance (Hedger *et al.*, 2008). Upon reaching the North Sea, the post-smolts are transported by water currents towards northern Norway and then into the Norwegian Sea (Jonsson *et al.*, 1993). Further evidence from Atlantic salmon from the east coast of Scotland (i.e. from the River Dee, River Tay and River North Esk) recaptured in Greenland and the Faroe Islands waters showed that smolts emigrated west to feed and grow (Malcolm *et al.*, 2010).

61. This is further supported by evidence from the Moray Firth (Gardiner *et al.*, 2018b, Newton *et al.*, 2019, Newton *et al.*, 2017), which suggests that smolts migrating from their rivers in the Moray Firth head directly across the North Sea relatively rapidly. Newton *et al.* (2017) also showed the majority remained predominantly within the upper 1 m of the water column during migration. Mortality of smolts was considered mainly attributable to predation and there was a strong relationship between group survival, early migration and group size. It is thought that this route, rather than moving in a coastal direction upon leaving their natal rivers, allows them to take advantage of east flowing currents which cross the North Sea. This fast progress away from the coast limits exposure to predators occurring close to the coast. Similar evidence of a rapid easterly migration out into the North Sea has also been shown for the River Dee in Aberdeenshire (Gardiner *et al.*, 2018a). Therefore, it could be assumed that smolts from other east coast rivers (e.g. the River Tay, River Dee, River South Esk, River Tweed, and River Teith) would move in a similar fashion.

62. Between 2018 to 2021, a tagging study was conducted on juvenile Atlantic salmon and sea trout migrating from the River Dee (River Dee Trust *et al.*, 2023). Atlantic salmon were found to travel at an average speed of 0.45 m/s from the river mouth to around 4 km offshore, before dropping to 0.24 m/s between 4 km to 20 km offshore (River Dee Trust *et al.*, 2023). Individuals mostly swam within the top 3 m of the water column and swam in an easterly direction in the first 4 km, before following a south-easterly trajectory. This pattern was consistent over the three years of the study, suggesting that this is a regular migratory route and that Atlantic salmon must make a northerly course adjustment at some point in their migration to reach higher latitude feeding grounds in the Norwegian Sea (River Dee Trust *et al.*, 2023). The authors concluded that this easterly and south-easterly migratory trajectory suggests that Atlantic salmon could be present in offshore areas of the North Sea.

63. Atlantic salmon numbers have declined throughout their geographic range, including in Scottish rivers (JNCC, 2024e, NatureScot, 2020c). The most recent wild Atlantic salmon total rod catch data reported 42,204 individuals in 2022, the fourth lowest record since the start of the statistics on salmon fisheries in Scotland by Marine Scotland in 1952 (Scottish Government, 2023). This is an increase from the 35,693 recorded in 2021 (Scottish Government, 2022), but still provides evidence of the population declines of Atlantic salmon in Scotland.

64. Atlantic salmon are of considerable cultural and conservation importance (Hindar *et al.*, 2011). The species is subject to many pressures in both marine and freshwater environments. These include pollution, the introduction of non-native salmon stocks, physical barriers to migration, exploitation from netting and angling, physical degradation of spawning and nursery habitat, and increased marine mortality (Oslo Paris Convention (OSPAR) Commission (2024)). Since 2016, as a result of the Salmon Conservation Regulations, Atlantic salmon caught in coastal waters must be released. This was implemented to prevent the killing of Atlantic salmon in coastal waters and estuaries to protect stocks that were in poor conservation status.

65. Alongside other salmonids (such as sea trout *Salmo trutta*), Atlantic salmon are host species for the parasitic larval phase of freshwater pearl mussel. Freshwater pearl mussel are strictly freshwater species and have seen population declines throughout their UK range. A decline in Atlantic salmon stocks is one of the factors corresponding to this population decline. As stated in paragraph 16, the potential impact s to Atlantic salmon can directly affect populations of Annex II freshwater pearl mussel, which has been assessed alongside Atlantic salmon in this Part of the RIAA.

Freshwater pearl mussel

66. Freshwater pearl mussels are long-lived freshwater molluscs that live in beds of clear, well-oxygenated, and fast-flowing rivers that are free of turbidity and pollution (JNCC, 2024d). They burrow into sandy substrates, often between boulders and pebbles (JNCC, 2024d). During their parasitic larval stage, they are dependent upon a healthy population of salmonids (young Atlantic salmon or sea trout) which act as host species (Taeubert *et al.*, 2017). Freshwater pearl mussel larvae attach to the gills of salmonid fish in mid to late summer and drop off the following spring. When they detach from their hosts they must land in sandy or gravelly substrates to settle and grow to adulthood (JNCC, 2024d). In suitable conditions they can live for over 100 years and grow up to 20 cm.

67. They are filter feeders, and are therefore particularly vulnerable to pollution and other changes in water quality (NatureScot, 2023b). Other threats to freshwater pearl mussels include hydrological alterations (including river engineering and abstractions), habitat degradation of river beds and banks, illegal fishing, and availability of host salmonids (JNCC, 2024d, NatureScot, 2023b).

68. The freshwater pearl mussel is widely distributed in Europe and north-eastern North America, but has suffered serious decline and is threatened with extinction or is highly vulnerable in every part of its former range (JNCC, 2024d, NatureScot, 2023b). It is listed as 'critically endangered' in Europe by the International Union for the Conservation of Nature and Natural Resources (IUCN) (Moorkens, 2011). The species was formerly widespread throughout western and northern parts of the UK. However, England and Wales are each now believed to support only a single recruiting population. In Northern Ireland the species formerly occurred widely in several catchments but is now restricted to a few sites (NatureScot, 2023b). Many UK rivers now contain only scattered individuals, with no juvenile mussels recorded; such populations may become extinct due to lack of recruitment. Despite serious declines in both range and

total population, Scotland is the remaining European stronghold for the species, supporting functional populations in over 50 rivers, mainly in the Highlands. Of the 26 SACs designated for freshwater pearl mussel, 19 are in Scotland, and four of these are included in this Part of the RIAA (e.g. the River Dee SAC, River South Esk SAC, River Spey SAC, and River Oykel SAC).

#### Conservation objectives

69. Conservation objectives for the River Dee SAC have been developed by NatureScot as part of a CAP (NatureScot, 2020c). Conservation objectives for all qualifying features of this SAC are:

- to ensure that the qualifying features of the River Dee SAC are in favourable condition and make an appropriate contribution to achieving FCS; and
- to ensure that the integrity of the River Dee SAC is restored by meeting objectives 2a, 2b, 2c for each qualifying feature (and 2d for freshwater pearl mussel) (NatureScot, 2020c).

70. Conservation objectives for freshwater pearl mussel are as follows:

- 2a. Restore the population of freshwater pearl mussel as a viable component of the site;
- 2b. Restore the distribution of freshwater pearl mussel throughout the site;
- 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food; and
- 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats (NatureScot, 2020c).

71. Conservation objectives for Atlantic salmon are as follows:

- 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site;
- 2b. Restore the distribution of Atlantic salmon throughout the site; and
- 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food (NatureScot, 2020c).

72. The overarching conservation objectives detailed in paragraph 69 are related to the species-specific conservation objectives 2a to 2c for Atlantic salmon and 2a to 2d for freshwater pearl mussel. Therefore, the assessment of the Array alone and in-combination with other plans and projects focuses on the individual species-specific conservation objectives. This allows a proportionate approach, as by demonstrating that potential impact s associated with the Array alone and in-combination with other plans and projects will not have an adverse effect on the species-specific conservation objectives (2a to 2c/2d), the overarching conservation objectives will therefore not be impaired.

#### Condition assessment

73. The condition of Atlantic salmon was assessed in 2011, and in 2014 for freshwater pearl mussel (NatureScot, 2020c). The outcomes of these feature condition assessments were as follows:

- freshwater pearl mussel: unfavourable – declining; and
- Atlantic salmon: favourable – maintained.

74. Freshwater pearl mussel was assessed as being in unfavourable condition due to the low number and density of freshwater pearl mussels present. This is due to low levels of juvenile recruitment, water flow, river morphology, the presence of filamentous algae, and water quality at the SAC (NatureScot, 2020c).

### 5.2.2. RIVER SOUTH ESK SAC

#### Site description

75. At its closes point, the River South Esk SAC is located 107.13 km west from the site boundary. The site is located in Angus in Eastern Scotland and covers 471.85 ha. The site is designated solely for Atlantic salmon and freshwater pearl mussel (NatureScot, 2020e).

#### Feature accounts

<u>Atlantic salmon</u>

76. The ecology of Atlantic salmon is as described above in section 5.2.1, and not repeated here. The SAC supports a large, high-quality Atlantic salmon population. The River South Esk has a strong nutrient gradient along its length, rising in the nutrient-poor Grampians and flowing for half of its length through the rich agricultural lands of Strathmore. The high proportion of the South Esk which is accessible to salmon and the range of ecological conditions in the river allows it to support the full range of life-history types found in Scotland, with sub-populations of spring, summer salmon and grilse all being present (JNCC, 2024g).

<u>Freshwater pearl mussel</u>

77. The ecology of freshwater pearl mussel is as described above in section 5.2.1, and not repeated here,. This species is abundant in the River South Esk and is highest in the middle reaches of the river where they attain densities > 20 $m^2$. The conservation importance of the site is further increased by the abundance of juveniles which comprise approximately 20% of the population. The presence of juvenile freshwater pearl mussels >20 mm long indicates that there has been successful recruitment since monitoring began in 1996 (JNCC, 2024g).

#### Conservation objectives

78. Conservation objectives for the River South Esk SAC have been developed by NatureScot as part of a CAP (NatureScot, 2020e). Conservation objectives for all qualifying features of the SAC are:

- to ensure that the qualifying features of the River South Esk SAC are in favourable condition and make an appropriate contribution to achieving FCS; and
- to ensure that the integrity of the River South Esk SAC is restored by meeting objectives 2a, 2b, 2c for each qualifying feature (and 2d for freshwater pearl mussel) (NatureScot, 2020e).

79. Conservation objectives for freshwater pearl mussel are as follows:

- 2a. Restore the population of freshwater pearl mussel as a viable component of the site;
- 2b. Restore the distribution of freshwater pearl mussel throughout the site;
- 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food; and
- 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats (NatureScot, 2020e).

80. Conservation objectives for Atlantic salmon are as follows:

- 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site;
- 2b. Restore the distribution of Atlantic salmon throughout the site; and
- 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food (NatureScot, 2020e).

81. The overarching conservation objectives detailed in paragraph 78 are related to the species-specific conservation objectives 2a to 2c for Atlantic salmon and 2a to 2d for freshwater pearl mussel. The assessment of the Array alone and in-combination with other plans and projects focuses on the individual species-specific conservation objectives. This allows a proportionate approach, as by demonstrating that potential impacts associated with the Array alone and in-combination with other plans and projects will not have an adverse effect on the species-specific conservation objectives (2a to 2c/2d), the overarching conservation objectives will therefore not be impaired.

#### Condition assessment

82. The condition of Atlantic salmon was assessed in 2011, and in 2009 for freshwater pearl mussel (NatureScot, 2020e). The outcomes of these feature condition assessments were as follows:

- freshwater pearl mussel: unfavourable – no change; and
- Atlantic salmon: unfavourable – recovering.

83. Freshwater pearl mussel was assessed as being in unfavourable condition due to the low number and density of freshwater pearl mussels present. This is due to low levels of juvenile recruitment, biological oxygen demand, and disturbance of mussel beds through largely historical fishing (NatureScot, 2020e).

### 5.2.3. TWEED ESTUARY SAC

#### Site description

84. At its closest point, the Tweed Estuary SAC is located 128.65 km south-west from the site boundary. The site, located in Northumberland, encompasses the Tweed Estuary, a long and narrow estuary discharging into the North Sea. The site covers an area of 155.93 ha. The site is designated for Annex I habitats and Annex II river lamprey and sea lamprey (with the latter being applicable to this Part of the RIAA) (Natural England, 2018).

#### Feature accounts

<u>Sea lamprey</u>

85. The sea lamprey is a primitive, jawless fish which resembles an eel. It is the largest of the three lamprey species found in the UK (with the other two being river lamprey and brook lamprey *Lampetra planeri*) (NatureScot, 2023c). As a diadromous species, the sea lamprey requires both freshwater and marine habitats during different phases of its life cycle. Adults require estuaries and easily accessible rivers with clean gravel substrates in which to spawn. Hatched larvae are referred to as ammocoetes, which drift downstream with the current and settle in nursery habitats with fine, soft substrate in well-oxygenated and slow-flowing freshwater (NatureScot, 2023c). Sea lamprey ammocoetes may remain in their freshwater nurseries for up to eight years before the metamorphose into adults and migrate to the marine environment, where they are parasitic predators on a range of different fish species (Hume, 2017; Maitland, 2003). These prey species include large fish, such as salmonids, but sea lamprey have been recorded as a parasitic predator on at least 54 different fish and marine mammal species (Silva *et al.*, 2014). Sea lamprey remain at sea for 18 to 24 months, before migrating upstream into freshwater spawning habitats between April and May. They spawn in May and June, and die after spawning (JNCC, 2023c). During spawning, they have preference for warm waters (JNCC, 2023c). In contrast to Atlantic salmon (see paragraph 58), there is no evidence of homing behaviour to natal rivers in sea lamprey (Scottish Government, 2019).

86. Sea lamprey are rarely captured in coastal and estuarine waters, suggesting that they are solitary hunters and widely dispersed at sea, and can be found at considerable depths (up to 4,099 m) (Scottish Government, 2019). As they are parasites during the adult marine phase of their life cycle, their distribution at sea is largely dictated by their host species (Scottish Government, 2019). As such it is not expected that they will be particularly attracted to structures associated with offshore wind developments. However, this is not certain, as there is limited information available on the utilisation of the marine environment by sea lamprey. It is a possibility that sea lamprey will be present in the vicinity of the Array.

87. The sea lamprey occurs over much of the Atlantic coastal area of western and northern Europe (from northern Norway to the western Mediterranean) and eastern North America, and is reasonably widespread in UK rivers (JNCC, 2023c). However, sea lamprey has declined in parts of its UK range and has become extinct in a number of rivers. It appears to reach its northern limit of distribution in Scotland and does not occur north of the Great Glen (see section 5.2.6) (JNCC, 2023c).

88. The Tweed Estuary SAC, together with the River Tweed SAC (see section 5.2.4), was designated for its significant presence of sea lamprey (Natural England, 2018). Sea lamprey migrates through the Tweed Estuary to reach freshwater spawning grounds in the main River Tweed and its tributaries in late May and June. Downstream juvenile migration occurs in July to September (Maitland, 2003). Given the difficulty in surveying sea lamprey larvae, they were only recorded in the lower part of the main river in the Tweed catchment in a 2004 dataset (NatureScot, 2020a). It is unclear whether or not this reflects the actual distribution of sea lamprey or whether it is due to the difficulties of sampling sea lamprey as reports of spawning and adults were historically more widespread over the catchment (NatureScot, 2020a). The 2004 dataset also presented evidence for three years of spawning sea lamprey in the lower Tweed (NatureScot, 2020a). However, a more recent survey in 2013 did not find any records of sea lamprey ammocoetes (Campbell, 2013).

89. Sea lamprey use the Tweed Estuary for migration and feeding between their freshwater spawning grounds and coastal waters. Man-made features such as weirs and dams, as well as polluted sections of the River Tweed may impede migration (Natural England, 2018). Within the adjacent freshwater River Tweed SAC (see section 5.2.4), sea lamprey need clean gravel for spawning, and marginal silt or sand for juveniles to burrow in (Natural England, 2018).

#### Conservation objectives

90. The conservation objectives for the Tweed Estuary SAC were developed by Natural England (2018). These high-level objectives ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the FCS of its qualifying features, by maintaining or restoring:

- the extent and distribution of qualifying natural habitats and habitats of the qualifying species;
- the structure and function (including typical species) of qualifying natural habitats;
- the structure and function of the habitats of the qualifying species;
- the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;
- the populations of each of the qualifying species; and
- the distribution of qualifying species within the site (Natural England, 2018).

91. The second conservation objective: 'the structure and function (including typical species) of qualifying natural habitats' is only relevant to the Annex I habitat features of the Tweed Estuary SAC and is therefore not included further in this assessment on Annex II diadromous fish features.

92. Supplementary advice on conservation objectives (last updated on 09 May 2023), provide the site-specific attributes and targets specific to the sea lamprey feature of the site. All targets for the sea lamprey feature have been set as 'Maintain' by Natural England, using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring/have occurred on the site (Natural England, 2023b). A summary of the conservation targets for sea lamprey are as follows:

- maintain the unrestricted usage of the estuary by adult and juvenile sea lamprey including for migratory passage and juvenile development;
- maintain the reproductive and recruitment capability of the species;

- maintain the presence and spatial distribution of the species and their ability to undertake key life cycle stages and behaviours;
- maintain connectivity of estuarine features to surrounding rivers, freshwater, marine and coastal habitats, to ensure larval dispersal and recruitment, maintain nursery grounds for mobile species, and to allow movement of migratory species;
- maintain the extent and spatial distribution of the following supporting habitats: water column;
- maintain the abundance of preferred food items required by the species;
- maintain the natural physico-chemical properties of the water;
- maintain all hydrodynamic and physical conditions such that natural water flow is not significantly altered or constrained;
- reduce aqueous contaminants to levels equating to High Status according to Annex VIII and Good Status according to Annex X of the Water Framework Directive (WFD), avoiding deterioration from existing levels. This target was set using the Environmental Agency 2019 water body classifications data;
- maintain the dissolved oxygen concentration at levels equating to High Ecological Status (specifically ≥ 5.7 mg/L (at 35 salinity) for 95% of year) avoiding deterioration from existing levels. This target was set using the Environmental Agency 2019 water body classifications data;
- maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing levels. This target was set using the Environmental Agency 2019 water body classifications data; and
- maintain natural levels of turbidity (e.g. concentrations of suspended sediment, plankton and other material) in areas where this species is, or could be present (Natural England, 2023b).

#### Condition assessment

93. The condition of the Tweed Estuary SAC's features had not been assessed at the time of writing (Natural England, 2018).

### 5.2.4. RIVER TWEED SAC

#### Site description

94. At its closest point, the River Tweed SAC is located 133.40 km south-west from the site boundary. The site, located in Eastern Scotland and Northumberland and Tyne and Wear encompasses 3,742.62 ha of the River Tweed's catchment and 1,285 km of watercourse (NatureScot, 2020h). The site is designated for Annex I habitats and Annex II species, including diadromous fish species relevant to this assessment: Atlantic salmon and sea lamprey.

#### Feature accounts

Atlantic salmon

95. The ecology of Atlantic salmon is as described above in section 5.2.1, and not repeated here,. The River Tweed supports a very large, high-quality population of Atlantic salmon, with sub-catchments in both Scotland and England. The river is the best example in the UK of a large river showing a strong nutrient gradient along its length, with oligotrophic conditions in its headwaters, and nutrient-rich lowland conditions just before it enters the sea at Berwick (JNCC, 2024k). The river supports the full range of salmon life history types, with sub-populations of spring, summer salmon and grilse all being present (JNCC, 2024k). Research by Gauld (2014) and Gauld *et al.* (2016) suggested that Atlantic salmon mainly spawn in the main lower stretches of the channel of the River Tweed. The extensive system supports a significant proportion of the Scottish salmon resource. In recent years, the salmon catch in the River Tweed is the highest in Scotland, with up to 15% of all salmon caught (JNCC, 2024k).

Sea lamprey

96. The ecology of sea lamprey is as described above in section 5.2.3, and not repeated here,. In the English waters of the River Tweed SAC, sea lamprey are believed to spawn in the lower reaches of the main river although features such as weirs and dams may impede migration to spawning grounds (Natural England, 2022). Sea lamprey seems to be relatively poor at ascending obstacles to migration (in comparison to river lamprey), and are frequently restricted to the lower reaches of rivers (Natural England, 2022). Within the River Tweed SAC, there are excellent examples of the features that sea lamprey needs for survival, including areas of silt, sand, gravel and cobbles in the middle to lower reaches of the river which provide suitable spawning and nursery habitat (Natural England, 2022).

#### Conservation objectives

97. The River Tweed SAC crosses the border between England and Scotland. Management of the River Tweed SAC is shared by Natural England and NatureScot and conservation objectives for the site have been published by both SNCBs (Natural England, 2022, NatureScot, 2020h). In this assessment, both sets of conservation objectives have been consulted as the features being assessed are diadromous fish, and therefore may migrate to and from the English or Scottish parts of the SAC.

98. A CAP for the River Tweed SAC has been developed by NatureScot (NatureScot, 2020h). Conservation objectives for Atlantic salmon and sea lamprey are:

- to ensure that the qualifying features of the River Tweed SAC are in favourable condition and make an appropriate contribution to achieving FCS; and
- to ensure that the integrity of the River Tweed SAC is restored by meeting objectives 2a, 2b, 2c for each qualifying feature (NatureScot, 2020h).

99. Conservation objectives for Atlantic salmon are as follows:

- 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site;
- 2b. Maintain the distribution of Atlantic salmon throughout the site; and
- 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food (NatureScot, 2020h).

100. Conservation objectives for sea lamprey are as follows:

- 2a. Maintain the population of the lamprey species' as viable components of the site;
- 2b. Maintain the distribution of the lamprey species throughout the site; and
- 2c. Maintain the habitats supporting the lamprey species within the site, and availability of food (NatureScot, 2020h).

101. The overarching conservation objectives detailed in paragraph 98 are related to the species-specific conservation objectives 2a to 2c for Atlantic salmon and sea lamprey. The assessment of the Array alone and in-combination with other plans and projects focuses on the individual species-specific conservation objectives. This allows a proportionate approach, as by demonstrating that potential impacts associated with the Array alone and in-combination with other plans and projects will not have an adverse effect on the species-specific conservation objectives (2a to 2c), the overarching conservation objectives will therefore not be impaired.

102. Conservation objectives and related supplementary advice developed by Natural England apply to those parts of the SAC lying in England (Natural England, 2022). The high-level objectives for the site are:

- to ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the FCS 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 the habitats of qualifying species rely;
- the populations of qualifying species; and
- the distribution of qualifying species within the site (Natural England, 2022).

103. The second conservation objective: 'the structure and function (including typical species) of qualifying natural habitats' is only relevant to the Annex I habitat features of the River Tweed SAC and is therefore not included further in this assessment on Annex II diadromous fish features.

104. Supplementary advice on conservation objectives (published on 31 August 2022) (Natural England, 2022) provides the site-specific attributes and targets specific to the Atlantic salmon and sea lamprey features of the SAC. Conservation targets for Atlantic salmon are summarised here:

- restore the population to that expected under un-impacted conditions, allowing for natural fluctuations;
- maintain juvenile densities at those expected under un-impacted conditions throughout the site, taking into account natural habitat conditions and allowing for natural fluctuations;
- restore the distribution of spawning to reflect un-impacted conditions through the site, and avoid reductions in existing levels;
- maintain or where necessary restore the distribution and continuity of the feature and its supporting habitat, including where applicable its component vegetation types and associated transitional vegetation types, across the site;
- maintain or where necessary restore the total extent of the habitats which support the feature at 156.20 km (the entire length of the English portion of the river), including habitat mosaics, supply of coarse and fine sediment, water flows, underlying soil types, water quality, vegetation, and thermal regime;
- the movement of other characteristic biota should not be artificially constrained;
- maintain or where necessary restore the feature's ability, and that of its supporting habitat, to adapt or evolve to wider environmental change, either within or external to the site;
- ensure non-native species categorised as 'high-impact' in the UK under the WFD are either rare or absent but if present are causing minimal damage to the feature;
- maintain or, where necessary, restore concentrations and deposition of air pollutants to at or below the site-relevant Critical Load or Level values given for this feature of the site;
- ensure exploitation (e.g. netting or angling) of Atlantic salmon is undertaken sustainably without compromising any components of the population, including multi-sea winter fish and seasonal components of the adult run;
- ensure fish stocking introductions do not interfere with the ability of the river to support self-sustaining populations of the feature; and
- maintain a sufficient proportion of all aquatic macrophytes to allow them to reproduce in suitable habitat and unaffected by river management practices (Natural England, 2022).

105. Natural England (2022) conservation targets for sea lamprey are summarised here:

- maintain or where necessary restore juvenile densities at those expected under unimpacted conditions throughout the site, taking into account natural habitat conditions and allowing for natural fluctuations;
- maintain or where necessary restore the abundance of the population to a level which is close to that expected under unimpacted conditions throughout the site (subject to natural habitat conditions and allowing for natural fluctuations), whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent;
- maintain or where necessary restore the distribution and continuity of the feature and its supporting habitat, including where applicable its component vegetation types and associated transitional vegetation types, across the site;
- maintain or where necessary restore the total extent of the habitats which support the feature at 156.20 km (the entire length of the English portion of the river), including habitat mosaics, nutrient regimes, supply of coarse and fine sediment, water flows, underlying soil types, water quality, vegetation, and thermal regime;
- the movement of other characteristic biota should not be artificially constrained;
- all exploitation (e.g. netting or angling) of sea lamprey should be undertaken sustainably without compromising any components of the population;
- ensure fish stocking/introductions do not interfere with the ability of the river to support self-sustaining populations of the features;
- all intakes and discharges likely to trap a significant number of individuals of characteristic species are being adequately screened;
- ensure non-native species categorised as 'high-impact' in the UK under the WFD are either rare or absent but if present are causing minimal damage to the feature;
- maintain or, where necessary, restore concentrations and deposition of air pollutants to at or below the site-relevant Critical Load or Level values given for this feature of the site; and
- maintain the feature's ability, and that of its supporting processes, to adapt or evolve to wider environmental change, either within or external to the site (Natural England, 2022).

#### Condition assessment

106. The condition of Atlantic salmon was assessed in 2011, and in 2018 for sea lamprey (NatureScot, 2020h). The outcome of the feature condition assessment was as follows:

- Atlantic salmon: favourable – maintained; and
- sea lamprey: unfavourable – declining (NatureScot, 2020h).

107. Sea lamprey was assessed as being in unfavourable condition at this SAC due to a restricted distribution within the Tweed catchment. The Mertoun weir at St Boswells is potentially a significant obstacle for sea lamprey, although other fish species are largely successful at migrating upstream of the structure (NatureScot, 2020h). Despite the presence of a fish pass, river flow rates over the weir, particularly during upstream migrations, may not be suitable for the species. As a result, sea lamprey may be largely restricted to the lower Tweed. Better evidence is required to provide a true picture of sea lamprey distribution at this SAC and the impacts of the Mertoun weir on this (NatureScot, 2020h).

108. Although the conservation objectives for sea lamprey are phrased in order to 'maintain' the species' population, distribution and habitats (paragraph 100), the condition assessment concluded the sea lamprey feature of this SAC to be in unfavourable declining condition (paragraph 106). Therefore, the conservation objectives for the sea lamprey feature of this SAC have been assessed throughout as 'maintained or restored' to account for this condition assessment.

### 5.2.5. RIVER TAY SAC

#### Site description

109. At its closest point, the River Tay SAC is located 162.32 km west from the site boundary. The site comprises the longest river in Scotland, originating in western Scotland, flowing easterly across the Highlands before becoming tidal at the Firth of Tay. The River Tay drains a very large catchment, and has the greatest flow of all UK rivers (JNCC, 2024i). The site covers an area of 9,461.63 ha. The site is designated for Annex I habitats and Annex II species including diadromous fish species relevant to this assessment: Atlantic salmon and sea lamprey (NatureScot, 2020g).

#### Feature accounts

<u>Atlantic salmon</u>

110. The ecology of Atlantic salmon is as described above in section 5.2.1, and not repeated here,. The River Tay supports a high-quality Atlantic salmon population, with rod catch returns showing that it is consistently one of the top three salmon rivers in Scotland (JNCC, 2024i). In 1999 the catch was 7,230 fish, over 10%

of the Scottish total (JNCC, 2024i). There is considerable ecological variety in the River Tay catchment, resulting in the SAC supporting the full range of salmon life history types found in Scotland, with adult salmon entering the River Tay throughout the year to spawn in different parts of the catchment (JNCC, 2024i).

111. As stated in paragraph 63, Atlantic salmon numbers have declined throughout their geographic range, including in Scottish rivers. At the River Tay, the proliferation of small scale hydro schemes, Invasive Non Native Species (INNS) such as the North American signal crayfish *Pacifastacus leniusculus,* and diffuse pollution from agriculture are having a notable impact upon the Atlantic salmon population (NatureScot, 2020g).

Sea lamprey

112. The ecology of sea lamprey is as described above in section 5.2.3, and not repeated here,. At the River Tay, the main issues that may affect sea lamprey are obstructions to passage (e.g. from hydro-schemes), diffuse pollution, and river engineering (NatureScot, 2020g).

#### Conservation objectives

113. Conservation objectives for the River Tay SAC have been developed by NatureScot as part of a CAP (NatureScot, 2020g). Conservation objectives for all qualifying species features are:

- to ensure that the qualifying features of River Tay SAC are in favourable condition; and
- to ensure that the integrity of the River Tay is maintained by meeting objectives 2a, 2b and 2c for each qualifying feature and make an appropriate contribution to achieving FCS (NatureScot, 2020g).

114. Conservation objectives for Atlantic salmon are as follows:

- 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site;
- 2b. Maintain the distribution of Atlantic salmon throughout the site; and
- 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food (NatureScot, 2020g).

115. Conservation objectives for sea lamprey are as follows:

- 2a. Maintain the population of sea lamprey as viable components of the site;
- 2b. Maintain the distribution of sea lamprey throughout the site; and
- 2c. Maintain the habitats supporting sea lamprey within the site, and availability of food (NatureScot, 2020g).

116. The overarching conservation objectives detailed in paragraph 113 are related to the species-specific conservation objectives 2a to 2c for Atlantic salmon and sea lamprey. The assessment of the Array alone and in-combination with other plans and projects focuses on the individual species-specific conservation objectives. This allows a proportionate approach, as by demonstrating that potential impacts s associated with the Array alone and in-combination with other plans and projects will not have an adverse effect on the species-specific conservation objectives (2a to 2c), the overarching conservation objectives will therefore not be impaired.

#### Condition assessment

117. The condition of sea lamprey was assessed in 2007 and Atlantic salmon condition was assessed in 2011. The outcomes of these feature condition assessments were as follows:

- Atlantic salmon: favourable – maintained; and
- sea lamprey: favourable – maintained (NatureScot, 2020g).

### 5.2.6. RIVER SPEY SAC

#### Site description

118. At its closest point, the River Spey is located 181.56 km north-west from the site boundary. The site, located in the Highlands and flowing into the Moray Firth, encompasses a total of 5,759.72 ha (NatureScot, 2020f). The site is designated for Annex II species, including diadromous fish features relevant to this assessment: Atlantic salmon, freshwater pearl mussel, and sea lamprey (NatureScot, 2020f).

#### Feature accounts

Atlantic salmon

119. The ecology of Atlantic salmon is as described above in section 5.2.1, and not repeated here. The River Spey supports one of Scotland's largest Atlantic salmon populations, with little evidence of modification by non-native stocks. Adults spawn throughout the whole length of the river, and good quality nursery habitat is found in abundance in the main river and numerous tributaries. The population includes fish of all ages including migrating smolts and returning adults (JNCC, 2024h). However, the Atlantic salmon population within the River Spey has shown a decrease in the spring multi-sea winter fish since 1952 (NatureScot, 2020f).

Freshwater pearl mussel

120. The ecology of freshwater pearl mussel is as described above in section 5.2.1, and not repeated here,. The River Spey is a large Scottish river which supports a freshwater pearl mussel population in its middle to lower reaches. In parts of the SAC, extremely dense mussel colonies have been previously been recorded and the total population was once estimated at several million (JNCC, 2024h).

121. In the River Spey, Atlantic salmon seem to be the most used host species for freshwater pearl mussel larvae (NatureScot, 2020f). Within the River Spey SAC, it is likely that freshwater pearl mussels have an artificially low population due to historic unsustainable fishing (NatureScot, 2020f).

Sea lamprey

122. The ecology of sea lamprey is as described above in section 5.2.3, and not repeated here,. The River Spey represents the most northern part of the sea lamprey's range in the UK, as the species is absent from rivers north of the Great Glen, and the River Spey is virtually at its northern limit (JNCC, 2024h). Recent surveys show that sea lamprey larvae are widely distributed throughout the middle and lower reaches of the river, where the particularly fast-flowing waters of the River Spey provide ideal spawning conditions for this species (JNCC, 2024h).

#### Conservation objectives

123. Conservation objectives for the River Spey SAC have been developed by NatureScot as part of a CAP (NatureScot, 2020f). Conservation objectives for all qualifying species features are:

- to ensure that the qualifying features of River Spey SAC are in favourable condition and make an appropriate contribution to achieving FCS; and
- to ensure that the integrity of the River Spey SAC is restored by meeting objectives 2a, 2b and 2c for each qualifying feature (and 2d for freshwater pearl mussel) (NatureScot, 2020f).

124. Conservation objectives for Atlantic salmon are as follows:

- 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site;
- 2b. Restore the distribution of Atlantic salmon throughout the site; and
- 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food (NatureScot, 2020f).

125. Conservation objectives for freshwater pearl mussel are as follows:

- 2a. Restore the population of freshwater pearl mussel as a viable component of the site;
- 2b. Restore the distribution of freshwater pearl mussel throughout the site;
- 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food; and
- 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats (NatureScot, 2020f).

126. Conservation objectives for sea lamprey are as follows:

- 2a. Maintain the population of sea lamprey as a viable component of the site;
- 2b. Maintain the distribution of sea lamprey throughout the site; and
- 2c. Maintain the habitats supporting sea lamprey within the site and availability of food (NatureScot, 2020f).

127. The overarching conservation objectives detailed in paragraph 123 are related to the species-specific conservation objectives 2a to 2c for Atlantic salmon and sea lamprey and 2a to 2d for freshwater pearl mussel. The assessment of the Array alone and in-combination with other plans and projects focuses on the individual species-specific conservation objectives. This allows a proportionate approach, as by demonstrating that potential impacts s associated with the Array alone and in-combination with other plans and projects will not have an adverse effect on the species-specific conservation objectives (2a to 2c/2d), the overarching conservation objectives will therefore not be impaired.

#### Condition assessment

128. The condition of Atlantic salmon and sea lamprey were assessed in 2011 and freshwater pearl mussel condition was assessed in 2014. The outcomes of these feature condition assessments were as follows:

- Atlantic salmon: unfavourable – recovering;
- freshwater pearl mussel: unfavourable – declining; and
- sea lamprey: favourable – maintained (NatureScot, 2020f).

129. Atlantic salmon was assessed as being in unfavourable condition at this SAC due to a decline in the number of salmon in the river, especially the spring salmon component of the population. The main issues include marine survival, water abstraction, dams and weirs, predation, and invasive non-native species. Marine mortality of adult salmon was also suggested as potentially contributing to the decline, but the scope of the CAP only covered measures that can be taken within the SAC (NatureScot, 2020f).

130. Freshwater pearl mussel monitoring in the River Spey SAC showed a significant apparent decrease in mussel density between 2000 and 2014. The small and isolated populations in the upper Spey were not recruiting and some appeared to have disappeared. Mussels are not successfully recruiting at an adequate density to maintain the population upstream of Grantown on Spey. As a result the site is in unfavourable condition for this feature (NatureScot, 2020f). The lack of recruitment in the upper Spey may be due to fine sediment causing anoxic conditions in the river gravels, which immature mussels cannot tolerate. Another issue could be poor water quality as there is lower flow in the upper river, and therefore less dilution (NatureScot, 2020f). Further, water crowfoot *Ranunculus fluitans* has been found to impact freshwater pearl mussels in the middle and lower Spey. This occurs through entanglement of mussels within the roots of water crowfoot, and smothering due to trapped sediment within these roots (NatureScot, 2020f).

### 5.2.7. BERRIEDALE AND LANGWELL WATERS SAC

#### Site description

131. At its closest point, the Berriedale and Langwell Waters SAC is located 219.57 km north-west from the site boundary. The site, located in the Highlands and flowing into the Moray Firth, encompasses 58.25 ha (JNCC, 2024a). The site is designated solely for Atlantic salmon.

#### Feature accounts

<u>Atlantic salmon</u>

132. The ecology of Atlantic salmon is as described above in section 5.2.1, and not repeated here,. The Berriedale and Langwell Waters SAC support small, but high-quality Atlantic salmon populations. The SAC is comprised of two comparatively small rivers and only supports a small proportion of the Scottish Atlantic salmon resource. However, their long history of low management intervention means that they score highly for naturalness. Recent records indicate that the full range of Atlantic salmon life-history types return to the river, with grilse, spring and summer salmon all being caught (JNCC, 2024a).

#### Conservation objectives

133. Conservation objectives for the Berriedale and Langwell Waters SAC have been developed by NatureScot as part of a CAP (NatureScot, 2020b). Overarching conservation objectives for this SAC are:

- to ensure that the qualifying feature of Berriedale and Langwell Waters SAC is in favourable condition and makes an appropriate contribution to achieving FCS;
- to ensure that the integrity of Berriedale and Langwell Waters SAC is maintained by meeting objectives 2a, 2b and 2c for Atlantic salmon (NatureScot, 2020b).

134. Specific Atlantic salmon conservation objectives for Atlantic salmon are as follows:

- 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site;
- 2b. Maintain the distribution of the species throughout the site; and
- 2c. Maintain the habitats supporting the species within the site and availability of food (NatureScot, 2020b).

135. The overarching conservation objectives detailed in paragraph 133 are related to the species-specific conservation objectives 2a to 2c for Atlantic salmon. The assessment of the Array alone and in-combination with other plans and projects focuses on the individual species-specific conservation objectives. This allows a proportionate approach, as by demonstrating that potential impacts s associated with the Array alone and in-combination with other plans and projects will not have an adverse effect on the species-specific conservation objectives (2a to 2c), the overarching conservation objectives will therefore not be impaired.

#### Condition assessment

136. The condition of Atlantic salmon was assessed in 2011 as:

- Atlantic salmon: favourable – maintained (NatureScot, 2020b).

### 5.2.8. RIVER TEITH SAC

#### Site description

137. At its closest point, the River Teith SAC is located 244.19 km south-west from the site boundary. The river begins in Loch Lomond and the Trossachs National Park and flows through Stirling and into the Firth of Forth. The SAC encompasses 1,289.33 ha and is designated for Annex II diadromous fish species, including Atlantic salmon and sea lamprey, which are relevant to this assessment (NatureScot, 2015).

#### Feature accounts

Atlantic salmon

138. The ecology of Atlantic salmon is as described above in section 5.2.1, and not repeated here,. Atlantic salmon are present as a qualifying feature of this SAC, but not a primary reason for site selection. This, in combination with no CAP available for this site, results in a lack of site-specific information about this species. However, it is noted in Standard Data From for this SAC that it is considered to support a significant presence of Atlantic salmon (JNCC, 2015).

Sea lamprey

139. The ecology of sea lamprey is as described above in section 5.2.3, and not repeated here,. The River Teith in eastern Scotland represents part of the sea lamprey's eastern range. The River Teith is the most significant tributary of the River Forth and young sea lampreys have been recorded throughout the lower reaches of the main river. The conservation importance of the River Teith is increased by the fact that, unlike many British rivers, it supports populations of all three lamprey species (including river lamprey and brook lamprey which are out with the scope of this RIAA) (JNCC, 2024j).

#### Conservation objectives

140. A CAP has not yet been published for the River Teith SAC. However, conservation objectives for all qualifying species have been defined to avoid deterioration of their habitats or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained, and that the site makes an appropriate contribution to achieving FCS for each of the qualifying species. The following conservation objectives are to be maintained in the long term for the qualifying species:

- the population of the species, including range of genetic types for Atlantic salmon, as a viable component of the site;
- the distribution of the species within site;
- the distribution and extent of habitats supporting the species;
- the structure, function and supporting processes of habitats supporting the species; and
- there is no significant disturbance of the species (NatureScot, 2015).

141. Conservation objectives specific to Atlantic salmon and sea lamprey (e.g. 2a, 2b, and 2c) were not provided (NatureScot, 2015).

#### Condition assessment

142. As stated in paragraph 37, there was no CAP available for the River Teith SAC at the time of writing, and therefore no condition assessments were available for Atlantic salmon and sea lamprey.

### 5.2.9. RIVER OYKEL SAC

#### Site description

143. At its closest point, the River Oykel is located 259.33 km north-west from the site boundary. The site is in the Highlands and flows into the Moray Firth. The SAC encompasses 921.46 ha and is designated solely for Annex II Atlantic salmon and freshwater pearl mussel (NatureScot, 2020d).

#### Feature accounts

Atlantic salmon

144. The ecology of Atlantic salmon is as described above in section 5.2.1, and not repeated here,. As stated in paragraph 63, Atlantic salmon numbers have declined throughout their geographic range, including in Scottish rivers. In the River Oykel, potential pressures to Atlantic salmon include: overexploitation, loss of habitat connectivity, habitat degradation, climate change-related changes to surface water temperature and hydrology, built development (such as hydropower on the River Cassley and a weir on the Tutim Burn which is a barrier to salmon reaching apparently suitable habitat upstream) and direct and diffuse pollution and inappropriate stocking with young salmon in the past (NatureScot, 2020d).

Freshwater pearl mussel

145. The ecology of freshwater pearl mussel is as described above in section 5.2.1, and not repeated here,. The River Oykel supports a high-quality freshwater pearl mussel population with high densities recorded at some locations, including a bed numbering several thousand individuals. There is also evidence of non non-surveyed populations in deep water that may increase the conservation importance of the river (JNCC, 2024f).

#### Conservation objectives

146. Conservation objectives for the River Oykel SAC have been developed by NatureScot as part of a CAP (NatureScot, 2020d). Conservation objectives for all qualifying species features are:

- to ensure that the qualifying features of River Oykel SAC are in favourable condition and make an appropriate contribution to achieving FCS; and
- to ensure that the integrity of the River Oykel SAC is restored by meeting objectives 2a, 2b, 2c for both features (and 2d for freshwater pearl mussel) (NatureScot, 2020d).

147. Conservation objectives for Atlantic salmon are as follows:

- 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site;
- 2b. Maintain the distribution of Atlantic salmon throughout the site; and
- 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food (NatureScot, 2020d).

148. Conservation objectives for freshwater pearl mussel are as follows:

- 2a. Restore the population of freshwater pearl mussel as a viable component of the site;
- 2b. Restore the distribution of freshwater pearl mussel throughout the site;
- 2c. Restore the habitats supporting the freshwater pearl mussel within the site and availability of food; and
- 2d. Maintain the distribution and viability of freshwater pearl mussel host species and their supporting habitats (NatureScot, 2020d).

149. The overarching conservation objectives detailed in paragraph 146 are related to the species-specific conservation objectives 2a to 2c for Atlantic salmon and 2a to 2d for freshwater pearl mussel. The assessment of the Array alone and in-combination with other plans and projects focuses on the individual species-specific conservation objectives. This allows a proportionate approach, as by demonstrating that potential impacts associated with the Array alone and in-combination with other plans and projects will not have an adverse effect on the species-specific conservation objectives (2a to 2c/2d), the overarching conservation objectives will therefore not be impaired.

Condition assessment

150. The condition of Atlantic salmon was assessed in 2011 and freshwater pearl mussel condition was assessed in 2015. The outcomes of these feature condition assessments were as follows:

- Atlantic salmon: favourable – recovered;
- freshwater pearl mussel: unfavourable – no change (NatureScot, 2020d).

151. Freshwater pearl mussel has been assessed as being in unfavourable condition at this SAC due to the low number and density of individuals present, low levels of juvenile recruitment, water quality, water flow and disturbance of mussel beds through illegal pearl fishing (NatureScot, 2020d).

## 5.3. ASSESSMENT OF THE ADVERSE EFECTS OF THE ARRAY ALONE

### 5.3.1. UNDERWATER NOISE GENERATED DURING PILING AND UXO CLEARANCE

152. The LSE[2] assessment during the HRA Stage One process identified that during the construction phase, LSE[2] could not be ruled out for the impact of underwater noise generated during piling and UXO clearance. This relates to the following sites and relevant Annex II diadromous fish features:

- River Dee SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.
- River South Esk SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.
- Tweed Estuary SAC;
  - sea lamprey.
- River Tweed SAC;
  - Atlantic salmon; and
  - sea lamprey.
- River Tay SAC;
  - Atlantic salmon; and
  - sea lamprey.
- River Spey SAC;
  - Atlantic salmon;
  - freshwater pearl mussel; and
  - sea lamprey.
- Berriedale and Langwell Waters SAC;
  - Atlantic salmon.
- River Teith SAC; and
  - Atlantic salmon; and
  - sea lamprey.
- River Oykel SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.

153. The MDS and designed in measures considered for the assessment of underwater noise during piling and UXO clearance are shown in Table 5.3 and Table 5.4, respectively.

**Table 5.3: MDS Considered for the Assessment of Potential Impacts to Annex II Diadromous Fish due to Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array Alone**

| Project Phase | MDS | Justification |
|---|---|---|
| Construction | **Piling**<br><br>Wind turbines:<br>• up to 265 semi-submersible floating wind turbine foundations with up to 6 anchors per foundation and one 4.5 m diameter pile per anchor (1,590 piles);<br>• absolute maximum scenario is for 100% of piles to be driven piles;<br>• maximum hammer energy of up to 3,000 kJ;<br>• up to 2 vessels piling concurrently at floating wind turbine anchors;<br>• minimum 950 m and maximum 30 km distance between concurrent piling events;<br>• up to 8 hours maximum piling per pile, therefore 3 piles installed over 24 hours;<br>• total duration of piling of 12,720 hours over 530 days; and<br>• total piling phase at floating wind turbine anchors of 63 months over a period of 7 years (within the 8 years construction phase).<br><br>Offshore Substation Platforms (OSPs):<br>• up to 3 large and 12 small OSP jacket foundations with up to 12 and 6 legs per foundation, respectively; 24 x 4.5 m (large) and 12 x 3.0 m (small) diameter piles per leg (total of 216 piles);<br>• maximum hammer energy of up to 4,400 kJ;<br>• only 1 vessel piling at any one time at OSP locations;<br>• up to 8 hours maximum piling per pile, therefore 3 piles installed over 24 hours and maximum 8 piles installed over 24 hours;<br>• total duration of piling of 1,728 hours over 72 days;<br>• total piling phase at OSP foundations will take place intermittently over a 72 month constriction period within the 8 year construction programme; and<br>• there is a potential for 2 vessels piling concurrently at either 2 wind turbine anchor locations or 1 wind turbine anchor and 1 OSP foundation. There may be up to 602 days in which piling may occur within the piling phase at floating wind turbine anchors and OSPs.<br><br>**UXO Clearance**<br>• clearance of up to 15 UXOs within the site boundary;<br>• theoretical maximum UXO size of up to 698 kg Net Explosive Quantity (NEQ), realistic maximum weight of 227 kg NEQ;<br>• UXO clearance campaign will involve the use of up to 2 vessels on site at any one time with up to 4 return trips;<br>• intention for clearance of all UXOs using low order techniques (subsonic combustion) with a single donor charge of up to 0.25 kg NEQ for each clearance event;<br>• up to 0.5 kg NEQ clearance shot for neutralisation of residual explosive material at each location;<br>• up to 2 detonations within 24 hours;<br>• total duration of UXO clearance campaign 8 days excluding any time lost due to weather conditions; and<br>• clearance during daylight hours only. | The largest hammer energy and the maximum spacing between two concurrent piling vessels could lead to the largest area of ensonification at any one time. Minimum spacing between concurrent piling represents the highest risk of injury to animals. Note that maximum design scenario assumes concurrent piling for wind turbine anchors as the MDS, but it may occur as a combination of wind turbine anchors and OSP foundations. The maximum number of days when piling occurs will result in the greatest temporal impact. In total, a maximum of two piling vessels will be piling at any one time.<br><br>Maximum number, theortetical and realistic maximum size of UXOs encountered within the site boundary is based on the UXO Hazard Assessment undertaken for the Array (Ordtek, 2022). Further detail on this is provided in Part 1 of the RIAA. Donor charge is the maximum required to initiate low order detonation. Assumption of a clearance shot of up to 0.5 kg at all locations, although noting that this may not always be required. |

**Table 5.4: Designed In Measures Considered for the Assessment of Potential Impacts to Annex II Diadromous Fish to Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase**

| Designed In Measures | Justification | How the Designed In Measure will be Secured |
|---|---|---|
| Implementation of soft start measures for UXO clearance using a sequence of small explosive charges detonated over set time intervals. | During piling operations, soft starts will be used. This will involve the implementation of lower hammer energies at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels. This measure will reduce the risk of injury to Annex II diadromous fish in the immediate vicinity of piling operations, either by allowing some species/individuals to flee the area before noise levels reach a level at which injury may occur, and/or by limiting the total amount of noise energy entering the environment. | UXO clearance will be subject to a separate Marine Licence application and EPS Licence as appropriate. Mitigation, including, implementation of low order disposal will be secured through the relevant Marine Licence and EPS licence. |
| Undertake UXO clearance using low order disposal techniques where technically feasible. | Low order techniques will be adopted wherever practicable (e.g. deflagration and clearance shots). However, as noted in paragraph 173, there is a small risk that low order could unintentionally arise in a high order detonation and therefore this scenario has also been considered in the assessment of effects. This measure will reduce the noise levels and the potential for injury to Annex II diadromous fish in the vicinity of UXO clearance operations. | UXO clearance will be subject to a separate Marine Licence application and EPS Licence as appropriate. Mitigation, including, implementation of low order disposal will be secured through the relevant Marine Licence and EPS licence. |

### Information to support the assessment

Hearing sensitivity of Annex II diadromous fish

154. Underwater noise can potentially have an adverse impact on various fish species ranging from physical injury and mortality to behavioural effects. Peer reviewed guidelines have been published by the Acoustical Society of America (ASA) and provide directions and recommendations for setting criteria (including injury and behavioural criteria) for fish. These guidelines (Popper *et al.*, 2014) provide the most relevant and best available guidelines for impacts of underwater noise on fish species (see volume 3, appendix 10.1 of the Array EIA Report for further detail).

155. The Popper *et al.* (2014) guidelines broadly group fish into the following categories according to the presence or absence of a swim bladder and on the potential for that swim bladder to improve the hearing sensitivity and range of hearing:

- Group 1: Fishes lacking swim bladders (e.g. elasmobranchs and flatfish). These species are only sensitive to particle motion, not sound pressure and show sensitivity to only a narrow band of frequencies;
- Group 2: Fishes with a swim bladder but the swim bladder does not play a role in hearing (e.g. salmonids and some Scombridae). These species are considered to be more sensitive to particle motion than sound pressure and show sensitivity to only a narrow band of frequencies;
- Group 3: Fishes with swim bladders that are close, but not connected, to the ear (e.g. gadoids and eels). These fishes are sensitive to both particle motion and sound pressure and show a more extended frequency range than Groups 1 and 2, extending to about 500 Hz; and
- Group 4: Fishes that have special structures mechanically linking the swim bladder to the ear (e.g. clupeids such as herring *Clupea harengus*, sprat *Sprattus sprattus* and shads *Alosa* spp.). These fishes are sensitive primarily to sound pressure, although they also detect particle motion. These species have a wider frequency range, extending to several kHz and generally show higher sensitivity to sound pressure than fishes in Groups 1, 2 and 3.

156. Sea lamprey are considered to be a Group 1 species, and therefore has relatively low sensitivity to underwater noise (Popper *et al.*, 2014). Lamprey species are known to have relatively simple ear structures (Popper *et al.*, 1987), with very few responses to auditory stimuli noted overall (Popper, 2005), except a slight swimming speed increase and decrease in resting behaviour when exposed to continuous low frequency noise of 50 to 200 Hz (Mickle *et al.*, 2018). This suggests a low vulnerability to impacts of noise overall. In contrast, Group 4 hearing specialist fish, such as herring, possess an otic bulla; a gas filled sphere that is connected to the swim bladder, which enhances hearing ability. This anatomy is not present in sea lamprey, although the gas filled swim bladder in Atlantic salmon may be involved in their hearing capability (Popper *et al.*, 2014). While there is no direct link to the inner ear, Atlantic salmon are able to detect lower noise frequencies and as such are considered to be a Group 2 species, and therefore have a higher hearing sensitivity to sea lamprey, but comparatively low with respect to Group 3 and Group 4 species (Popper *et al.*, 2014).

157. Freshwater pearl mussel may only be indirectly affected by underwater noise as they are a freshwater-resident species, and piling will only occur within the site boundary, which is around 80 km offshore. Therefore, the effects of underwater noise upon freshwater pearl mussel assessed in this section are limited to indirect effects, due to potential disruption to Atlantic salmon migration.

Overview of underwater noise modelling conducted for the Array

158. Piling and UXO clearance activities may lead to injury and/or disturbance to Annex II diadromous fish species. The MDS (Table 5.3) considers the reasonable worst case scenario from underwater noise generated during piling based on the greatest hammer energy. This scenario is represented by the installation of up to 265 semi-submersible floating wind turbine foundations, with up to six anchors per foundation and one 4.5 m diameter pile per anchor (1,590 piles) for wind turbines, and up to three large and 12 small jacket foundations (total 216 piles) for OSPs, with all piles assumed to be installed via impact piling as the most precautionary scenario.

159. For wind turbines, piling was assumed to take place over a period of up to eight hours per pile with up to eight piles installed in each 24 hour period. OSP foundations will take place over 25 hours for up to three piles (maximum duration of up to eight hours per pile) with up to eight piles installed in each 24 hour period. A maximum duration of 1,728 hours of piling activity, over a maximum of 72 months over eight years, may take place during the construction phase, based on the maximum duration of the piling phase.

160. Underwater noise modelling was undertaken for both single piling and concurrent piling (i.e. piling at more than one location simultaneously). To ensure a precautionary assessment, modelling of a concurrent piling scenario based on a 3,000 kJ hammer energy for the wind turbine foundation piles and 4,400 kJ hammer energy for the OSP jacket piles has been undertaken, alongside single piling scenarios, using the maximum 4,400 kJ hammer energy for the OSP jacket piles. These are discussed further below in relation to injurious effects with relevant contours also presented and discussed in the context of potential behavioural effects on Annex II diadromous fish (specifically disruption and barriers to migration).

161. If required, UXO clearance (including detonation) will be completed prior to the construction phase (pre-construction). The MDS (Table 5.3) assumes clearance of up to 15 UXOs within the site boundary, with a maximum of 698 kg NEQ. The UXO clearance campaign will involve subsonic combustion with a single donor charge of up to 0.025 kg NEQ for each clearance event, and up to 0.5 kg NEQ to neutralise residual

explosive material at each location. Total duration of UXO clearance campaigns is eight days, with up to two detonations within 24 hours although it is noted that this may not always be required.

162. To understand the magnitude of noise emissions from piling and UXO clearance during construction activity, underwater noise modelling has been undertaken considering the key design parameters summarised above. Compared to piling, UXO detonations will be single, isolated events of very short duration; as such, potential behavioural effects upon Annex II diadromous fish will be extremely short lived and reversible. Full detail on the underwater noise modelling is provided in volume 3, appendix 10.1 of the Array EIA Report, and is summarised in terms of injury and disturbance in paragraphs 163 to 185.

Injury from piling (permanent and temporary)

163. The Popper *et al.* (2014) guideline criteria for the onset of mortality, recoverable injury, and Temporary Threshold Shift (TTS) due to impulsive piling are presented in Table 5.5. A dual criteria approach has been adopted in the guidelines to account for the uncertainties associated with the effects of underwater noise on fish. This includes two parameters for assessment: Cumulative Sound Exposure Level ($SEL_{cum}$) and $SPL_{pk}$.

164. It should be noted that the $SPL_{pk}$ thresholds for mortality and potential mortal injury and recoverable injury are the same (Table 5.5). The data on mortality and recoverable injury used by Popper *et al.* (2014) are derived from Halvorsen *et al.* (2011), Halvorsen *et al.* (2012a), and Halvorsen *et al.* (2012b), based on 960 sound events at 1.2 second intervals. The same Single Strike SEL ($SEL_{ss}$) was used throughout these Halvorsen *et al.* piling studies, therefore, the same peak level was derived ($SPL_{pk}$) as part of the criteria by Popper *et al.* (2014).

**Table 5.5: Criteria for the Onset of Mortality, Recoverable Injury, and TTS due to Impulsive Piling for Relevant Annex II Diadromous Fish Species (Popper *et al.*, 2014)**

| Hearing Group | Parameter | Mortality and Potential Mortal Injury | Recoverable Injury | TTS |
|---|---|---|---|---|
| 1: Fish with no swim bladder (e.g. sea lamprey) | $SEL_{cum}$, dB re 1 µPa²s | >219 | >216 | >186 |
| | $SPL_{pk}$, dB re 1 µPa | >213 | >213 | - |
| 2: Fish where the swim bladder is not involved in hearing (e.g. Atlantic salmon) | $SEL_{cum}$, dB re 1 µPa²s | 210 | 203 | >186 |
| | $SPL_{pk}$, dB re 1 µPa | >207 | >207 | - |

165. To inform the assessment on Annex II diadromous fish, predicted injury ranges associated with the installation of one 4.5 m diameter pile have been presented. This modelling resulted in the greatest predicted injury ranges and therefore forms the focus of the assessment for injury, noting that in most cases, the maximum hammer energy would not be reached during piling. The metrics presented are for $SEL_{cum}$ for fleeing fish and static fish (Table 5.6) and $SPL_{pk}$ (Table 5.7). A swim speed of 0.5 m/s was used to model fleeing fish (Popper *et al.*, 2014).

166. For the $SEL_{cum}$ metric, the injury ranges presented indicate that mortality and recoverable injury may occur out to ranges of tens of metres, based on the MDS for fleeing receptors (e.g. 15 m to 20 m for sea lamprey and 32 m to 110 m for Atlantic salmon (Table 5.6). If modelled as static receptors, the mortality and recoverable injury ranges increased to the low hundreds of metres for sea lamprey and up to 2,300 m for Atlantic salmon (Table 5.6). For both species, the TTS ranges were 8,380 m as fleeing receptors and 13,200 m as static receptors (Table 5.6). Practically, the risk of injury will be considerably lower due to the hammer energies being lower than the absolute maximum modelled (3,000 kJ). The expected fleeing behaviour of fish when exposed to high levels of noise and the implementation of soft starts mean that it is likely that fish will have ample time to vacate the areas in which injury may occur prior to noise levels reaching the maximum modelled; however there are uncertainties as to whether all fish species will flee from piling noise and as such static receptors were also modelled, noting these are likely to be highly precautionary ranges.

167. For peak pressure noise levels when piling energy is at its maximum for the wind turbine foundation pile installation, mortality and recoverable injury may occur within approximately 266 m and 414 m of the piling source for sea lamprey and Atlantic salmon, respectively (Table 5.7).

168. When piling for OSP foundations (i.e. maximum hammer energy of 4,400 kJ; Table 5.8), greater injury ranges are predicted than for single piling of wind turbine foundations. Using the $SEL_{cum}$ metric for fleeing fish, mortality and recoverable injury may occur out to ranges between 25 m and 31 m for sea lamprey and 112 m and 1,440 m for Atlantic salmon (Table 5.8). If modelled as static receptors, the mortality and recoverable injury ranges increase to 855 m and 1,220 m, respectively, for sea lamprey and 2,440 m and 5,120 m for Atlantic salmon (Table 5.8). For both species, the TTS ranges were 21,100 m as fleeing receptors and 26,960 m as static receptors (Table 5.8). Modelling using the peak SPL metric showed a similar pattern with mortality and recoverable injury to ranges of up to 615 m for sea lamprey and up to 1,055 m for Atlantic salmon under the maximum hammer energy of 4,400 kJ (Table 5.9).

169. Based on the two noise criteria ($SEL_{cum}$ and $SPL_{pk}$), injury will occur in the range of tens to hundreds of metres (Table 5.6 to Table 5.9), with larger injury ranges predicted for the maximum hammer energy of 4,400 kJ used during OSP jacket pile installation. However, the modelling has been informed by the maximum hammer energies within the MDS, which, in most cases, will not be reached. Additionally, injury ranges at the start of each piling sequence will be much smaller than those presented here, due to soft starts; at 660 kJ for OSP foundations and 450 kJ for foundation piles.

**Table 5.6: Potential Mortality, Injury, and TTS Ranges for Single Wind Turbine Foundation Pile Installation at 3,000 kJ based on the $SEL_{cum}$ Metric for Fleeing and Static Annex II Diadromous Fish**

| Hearing Group | Response | Threshold $SEL_{cum}$ (dB re 1 µPa²s) | Range (m): Fleeing Fish | Range (m): Static Fish |
|---|---|---|---|---|
| 1: Fish with no swim bladder (e.g. sea lamprey) | Mortality | 219 | 15 | 328 |
| | Recoverable injury | 216 | 20 | 472 |
| | TTS | 186 | 8,380 | 13,200 |
| 2: Fish where the swim bladder is not involved in hearing (e.g. Atlantic salmon) | Mortality | 210 | 32 | 1,015 |
| | Recoverable injury | 203 | 110 | 2,300 |
| | TTS | 186 | 8,380 | 13,200 |

**Table 5.7: Potential Mortality and Injury Ranges for Single Wind Turbine Foundation Pile Installation at 3,000 kJ based on the $SPL_{pk}$ Metric for Annex II Diadromous Fish**

| Hearing Group | Response | Threshold $SPL_{pk}$ (dB re 1 µPa) | Range (m) |
|---|---|---|---|
| 1: Fish with no swim bladder (e.g. sea lamprey) | Mortality | 213 | 266 |
| | Recoverable injury | 213 | 266 |
| 2: Fish where the swim bladder is not involved in hearing (e.g. Atlantic salmon) | Mortality | 207 | 414 |
| | Recoverable injury | 207 | 414 |

**Table 5.8: Potential Mortality, injury, and TTS Ranges for Single OSP Jacket Pile Installation at 4,400 kJ Based on the $SEL_{cum}$ Metric for Fleeing and Static Annex II Diadromous Fish**

| Hearing Group | Response | Threshold $SEL_{cum}$ (dB re 1 µPa²s) | Range (m): Fleeing Fish | Range (m): Static Fish |
|---|---|---|---|---|
| 1: Fish with no swim bladder (e.g. sea lamprey) | Mortality | 219 | 25 | 855 |
| | Recoverable injury | 216 | 37 | 1,220 |
| | TTS | 186 | 21,100 | 26,960 |
| 2: Fish where the swim bladder is not involved in hearing (e.g. Atlantic salmon) | Mortality | 210 | 112 | 2,440 |
| | Recoverable injury | 203 | 1,440 | 5,120 |
| | TTS | 186 | 21,100 | 26,960 |

**Table 5.9: Potential Mortality and Injury Ranges for Single OSP Jacket Pile Installation at 4,400 kJ based on the $SPL_{pk}$ Metric for Annex II Diadromous Fish**

| Hearing Group | Response | Threshold $SPL_{pk}$ (dB re 1 µPa) | Range (m) |
|---|---|---|---|
| 1: Fish with no swim bladder (e.g. sea lamprey) | Mortality | 213 | 615 |
| | Recoverable injury | 213 | 615 |
| 2: Fish where the swim bladder is not involved in hearing (e.g. Atlantic salmon) | Mortality | 207 | 1,055 |
| | Recoverable injury | 207 | 1,055 |

170. The MDS considers the potential for up to two pile installation vessels operating concurrently (Table 5.3). The potential $SEL_{cum}$ injury ranges for Annex II diadromous fish due to impact driving of piles have been modelled as following the same piling plans with all phases starting at the same time. For injury, the MDS is that of two adjacent piles, separated by a distance of 950 m in order to assume the maximal overlap of noise propagation contours leading to the maximum generated noise levels. Conversely, for disturbance, the maximum separation between two piling locations would lead to the larger area ensonified at any one time and therefore the greatest disturbance (discussed in paragraph 176 *et seq.*).

171. As per the MDS, there is potential for two vessels to be piling concurrently at one wind turbine and one OSP foundation (Table 5.3). Injury ranges for concurrent piling of OSP jacket installation at 4,400 kJ and wind turbine foundation installation at 3,000 kJ at each site are given in Table 5.10. The peak metric will remain the same as the single installation case (Table 5.7 and Table 5.9). For all other piling scenarios, injury ranges would be smaller; the full range of modelled scenarios are given in volume 3, appendix 10.1 of the Array EIA Report. As expected, these show that for this precautionary cumulative piling scenario, injury ranges are similar or slightly larger than the single piling scenarios for fleeing fish, but considerably larger (e.g. double the ranges) for static fish.

**Table 5.10: Potential Mortality, Recoverable Injury, and TTS Ranges for Concurrent OSP Jacket Piling (4,400 kJ) and Wind Turbine Foundation Piling (3,000 kJ) based on the $SEL_{cum}$ Metric for Fleering and Static Annex II Diadromous Fish**

| Hearing Group | Response | Threshold SEL (dB re 1 µPa²s) | Range (m): Fleeing fish | Range (m): Static fish |
|---|---|---|---|---|
| 1: Fish with no swim bladder (e.g. sea lamprey) | Mortality | 219 | 26 | 1,680 |
| | Recoverable injury | 216 | 40 | 2,360 |
| | TTS | 186 | 31,200 | 45,100 |
| 2: Fish where the swim bladder is not involved in hearing (e.g. Atlantic salmon) | Mortality | 210 | 143 | 4,460 |
| | Recoverable injury | 203 | 1,920 | 9,060 |
| | TTS | 186 | 31,200 | 45,100 |

Injury from UXO clearance

172. Underwater noise modelling was undertaken for UXO clearance. The criteria used in this underwater noise assessment for explosives are given in Table 5.11 following Popper *et al.* (2014). The recoverable injury and TTS criteria are categorised in relative terms as 'high', 'moderate', or 'low' at three distances from the source: 'near' (i.e. in the tens of metres), 'intermediate' (i.e. in the hundreds of metres), or 'far' (i.e. in the thousands of metres), as shown in Table 5.11. It is important to note that these criteria are qualitative rather than quantitative.

**Table 5.11: Criteria for the Onset of Mortality, Recoverable Injury, and TTS due to UXO Clearance for Relevant Annex II Diadromous Fish Species (Popper *et al.*, 2014)**

| Hearing Group | Parameter | Mortality and Potential Mortal Injury | Recoverable Injury | TTS |
|---|---|---|---|---|
| 1: Fish with no swim bladder (e.g. sea lamprey) | Peak, dB re 1µPa | 229 – 234 | (Near) High risk<br>(Intermediate) Low risk<br>(Far) Low | (Near) High risk<br>(Intermediate) Moderate risk<br>(Far) Low risk |
| 2: Fish where the swim bladder is not involved in hearing (e.g. Atlantic salmon) | Peak, dB re 1µPa | 229 – 234 | (Near) High risk<br>(Intermediate) High risk<br>(Far) Low risk | (Near) High risk<br>(Intermediate) Moderate risk<br>(Far) Low risk |

173. Modelling was undertaken for a range of orders of detonation, from the maximum high order detonation (698 kg) to low order detonations (e.g. deflagration and clearance shots), which will be used as mitigation to reduce noise levels. Table 5.12 details the injury ranges in relation to various orders of detonation. The method of low order has been committed to (Table 5.4), and as such will be the dominant method of UXO clearance, although higher order detonations may also occur if low order is not successful or unintentionally as part of the low order process.

174. The predicted injury ranges for low and high order disposal order detonations of UXOs are presented in Table 5.12 and demonstrate the effectiveness of the low order methods to reduce the risk of injury (i.e. injury ranges of tens of metres for low order, but up to 930 m for high order detonations).

175. Due to a combination of dispersion (i.e. where the waveform elongates), multiple reflections from the sea surface, and seabed and molecular absorption of high frequency energy, the noise is unlikely to still be impulsive once it has propagated more than a few kilometres. Consequently, caution should be used when interpreting any results with predicted injury ranges in the order of tens of kilometres. Furthermore, the modelling assumes that the UXO acts like a charge suspended in open water whereas it is likely to be partially buried in the sediment. In addition, it is possible that the explosive material will have deteriorated over time meaning that the predicted noise levels are likely to be over-estimated. Overall, these factors mean that the results should be treated as precautionary potential impact ranges and are likely to be significantly lower than predicted.

**Table 5.12: Potential Impact Ranges for UXO Clearance Activities, based on the Criteria Presented in Table 5.11**

| UXO Type | PTS Range (lower range*) (m) | PTS Range (upper range*) (m) |
|---|---|---|
| 0.25 Low order Donor charge | 40 | 67 |
| 0.5 kg Clearing Shot | 51 | 85 |
| 227 kg UXO – High Order Explosion | 640 | 384 |
| 698 kg UXO – High Order Explosion | 930 | 558 |

*The lower range and upper range refer to those provided within volume 3, appendix 10.1 of the Array EIA Report, based upon the Popper *et al.* (2014) guidance for explosions, where thresholds are quoted as ranges. Values presented herein reflect those associated with the extremes of the ranges presented within volume 3, appendix 10.1 of the Array EIA Report.

Behavioural disturbance (including TTS as a proxy)

176. Behavioural reactions of fish to underwater noise have been found to vary between species and depend on hearing sensitivity. Typically, fish sense noise via particle motion in the inner ear which is detected from noise-induced motions in the fish's body. The detection of sound pressure is restricted to those fish which have air filled swim bladders; however, particle motion (induced by noise) can be detected by fish without swim bladders (e.g. sea lamprey). Further, the presence of a swim bladder does not necessarily mean that the fish can detect pressure. Some fish have swim bladders that are not involved in the hearing mechanism and can only detect particle motion (e.g. Atlantic salmon).

177. Popper *et al.* (2014) provides qualitative behavioural criteria for fish from a range of noise sources. The behavioural criteria categorise the risks of effects as 'high', 'moderate', or 'low' at three distances from the source: 'near' (i.e. in the tens of metres), 'intermediate' (i.e. in the hundreds of metres), or 'far' (i.e. in the thousands of metres). It is important to note that the Popper *et al.* (2014) criteria for disturbance due to noise are qualitative rather than quantitative, due to a lack of agreed quantitative behavioural response thresholds (e.g. as set out for injury above). Consequently, a source of noise of a particular type (e.g. piling) would be predicted to result in the same potential impact, no matter the level of noise produced or the propagation characteristics. The behavioural criteria for piling operations are summarised in Table 5.13 for the relevant Annex II diadromous fish hearing groups and indicate a high to moderate risk of behavioural effects in the near and intermediate fields (i.e. up to hundreds of metres) and a low risk of behavioural effects in the far field (i.e. thousands of metres). As noted above, these criteria were developed for piling in general, with no consideration of piling characteristics, propagation, site specific considerations etc.

**Table 5.13: Potential Risk for the Onset of Behavioural Effects in Relevant Annex II Diadromous Fish from Piling (Popper *et al.*, 2014)**

| Hearing Group | Masking | Behaviour |
|---|---|---|
| 1: Fish with no swim bladder (e.g. sea lamprey) | (Near) Moderate risk<br>(Intermediate) Low risk<br>(Far) Low risk | (Near) High risk<br>(Intermediate) Moderate risk<br>(Far) Low risk |
| 2: Fish where the swim bladder is not involved in hearing (e.g. Atlantic salmon) | (Near) Moderate risk<br>(Intermediate) Low risk<br>(Far) Low risk | (Near) High risk<br>(Intermediate) Moderate risk<br>(Far) Low risk |

178. Additional studies have examined the behavioural effects of the sound pressure component of impulsive noise (including piling operations) on a range of fish species. For example, Mueller-Blenkle *et al.* (2010) recorded behavioural responses of cod *Gadus morhua* and sole *Solea solea* to sounds similar to those produced during marine piling, with variation noticed across specimens (i.e. depending on the age, sex, condition etc. of the fish, as well as the possible effects of confinement in cages on the overall stress levels in the fish). This study concluded that it was not possible to find a clear relationship between the level of exposure and the extent of the behavioural response, although an observable behavioural response was reported at 140 dB to 161 dB re 1 μPa $SPL_{pk}$ for cod and 144 dB to 156 dB re 1 μPa $SPL_{pk}$ for sole (Mueller-Blenkle *et al.*, 2010). Regardless, these thresholds should not be interpreted as the level at which an avoidance reaction will be elicited, as the study was not able to show this.

179. Further, a study by Pearson *et al.* (1992) examined the effects of geophysical survey noise on caged rockfish *Sebastes* spp. and observed a startle or "C-turn response" at peak pressure levels beginning around 200 dB re 1 μPa. This response was less common with the larger fish. Studies by McCauley *et al.* (2000) exposed various fish species in large cages to seismic airgun noise and assessed behaviour, physiological and pathological changes. The study observed that:

- a general fish behavioural response was to move to the bottom of the cage during periods of high level exposure (greater than rms levels of around 156 dB to 161 dB re 1 μPa; approximately equivalent to $SPL_{pk}$ levels of around 168 dB to 173 dB re 1 μPa);
- a greater startle response was seen in small fish to the above levels;
- a return to normal behavioural patterns was noticed some 14 to 30 minutes after airgun operations ceased;
- no significant physiological stress increases attributed to air gun exposure; and
- some preliminary evidence of damage to the hair cells was noticed when exposed to the highest levels, although it was determined that such damage would only likely occur at short range from the source (McCauley *et al.*, 2000).

180. Post construction monitoring at the Beatrice Offshore Wind Farm concluded that there were no evidence of adverse effects on sandeel (Ammodytidae) and cod populations between pre and post construction levels over a six year period (Beatrice Offshore Wind Farm Limited, 2021a, 2021b). Based on these studies, it can therefore be assumed that noise impacts associated with installation of an offshore wind development are temporary and that fish communities (specifically cod and sandeel in this case) show a high degree of recoverability following construction.

181. With specific reference to diadromous fish, Harding *et al.* (2016) failed to produce physiological or behavioural responses in Atlantic salmon when subjected to noise similar to piling. However, the noise levels tested were estimated at <160 dB re 1μPa (rms), below the level at which injury or behavioural disturbance would be expected for Atlantic salmon. Nedwell *et al.* (2006) used the slightly less sensitive sea trout as a model for comparison to Atlantic salmon, and found no significant behavioural response from piling activities, with modelling suggesting a similar response in Atlantic salmon and sea trout. Bagočius (2015) reported physical impacts on migrating salmonids exposed to piling noise of 218 dB re $1μPa^2s$ (SEL), although at these high noise levels, it would be expected that avoidance reactions would occur, to avoid injury.

182. Noting that there are no published or agreed thresholds for behavioural effects on fish from piling operations, a risk based approach has been undertaken using published literature on the behavioural responses of fish to underwater noise (paragraphs 181 to 180). Based on these studies, modelling has been presented using the 160 dB ($SPL_{pk}$) noise contour to assess behavioural responses in fish species in general and, for the purposes of this report in Atlantic salmon and sea lamprey (Figure 5.2 and Figure 5.3). It is unlikely that species will experience behavioural disturbance beyond this noise contour, based on the described studies which demonstrated behavioural responses (including avoidance) at levels above this threshold. It's likely that 160 dB re 1 μPa ($SPL_{pk}$) is over conservative, given that Atlantic salmon and sea lamprey are at the lower end of the sensitivity spectrum (i.e. hearing groups 1 and 2). The 160 dB ($SPL_{pk}$) contour is presented on Figure 5.2 and Figure 5.3 for the maximum north and south piling locations using the maximum hammer energy of 4,400 kJ (noting all other hammer energies will result in smaller contours). The extent of the 160 dB ($SPL_{pk}$) contour should be noted, particularly in terms it's considerable distance offshore, and its relatively small area of effect in terms of the availability of habitat in the North

Sea. While the 150 dB (SPL$_{pk}$) does extend closer to the shore, particularly for the northern location (Figure 5.2), behavioural disturbance is highly unlikely at this level (based on the studies outlined above).

183. In addition to this site specific noise modelling has considered criteria presented in the Washington State Department of Transport (WSDOT) Biological Assessment Preparation for Transport Projects Advanced Training Manual (WSDOT, 2011) in this assessment for estimating the distances at which behavioural effects may occur due to noise from impulsive piling (as set out see volume 3, appendix 10.1 of the Array EIA Report). The manual suggests an unweighted sound pressure level of 150 dB re 1 µPa (SPLroot mean square (rms)) as the criterion for onset of behavioural effects, based on work by Hastings (2002). Sound pressure levels in excess of 150 dB re 1 µPa (rms) are expected to cause temporary behavioural changes, such as elicitation of a startle response, disruption of feeding, or avoidance of an area. The document notes that levels exceeding this threshold are not expected to cause direct permanent injury but may indirectly affect the individual fish (such as by impairing predator detection). It is important to note that this threshold is for onset of potential effects, and not necessarily an ‘adverse effect’ threshold.

184. The underwater noise modelling (using the WSDOT (2011) 150 dB re 1 µPa (rms) criterion for the onset of behavioural effects) suggests behavioural responses may extend up to 33 km for single pin piling with a hammer energy of 3,000 kJ (representative of the MDS for wind turbine foundation installation). For a hammer energy of 4,400 kJ (thus representative of the MDS for OSP installation), this range was modelled out to a maximum range of 49 km from piling activity; noting these ranges will be highly conservative for the less sensitive diadromous species considered here. In some cases (e.g. previous offshore wind projects), TTS has been used as a proxy for behavioural disturbance. The maximum TTS values for single piling with hammer energy of 3,000 kJ were 13.20 km (Table 5.6), 26.96 km for a hammer energy of 4,400 kJ for OSP installation (Table 5.8), and 45.10 km for concurrent piling (Table 5.10). These ranges are therefore, of a similar magnitude (i.e. low tens of kilometres) as those ranges reported for the WSDOT criteria summarised above for the two maximum hammer energies and are likely representative of the absolute maximum ranges of behavioural disturbance to diadromous fish species. The 160 dB (SPL$_{pk}$) contour presented in Figure 5.2 and Figure 5.3 also extends to the low tens of kilometres from the piling location, further strengthening the conclusion that significant behavioural responses (i.e. those that may lead to disruption of migration or barrier effects) are unlikely beyond this range. As described in paragraph 171, the peak metric will remain the same for both single and consecutive piling. As the single piling scenarios presented in Figure 5.2 and Figure 5.3 are based on the peak metric, potential disturbance ranges will not increase the risk of barrier effects under consecutive piling scenarios.

185. Due to the distance between the Array and the coast (approximately 80 km), these behavioural impacts are unlikely to cause barrier effects to diadromous species as they migrate along the east coast of Scotland, due to the relatively limited area around piling events where noise levels are high enough to cause behavioural responses in the context of the wider fish and shellfish ecology study area (as illustrated in Figure 5.2 and Figure 5.3 and extrapolated from the information presented in paragraph 176 *et seq.*).

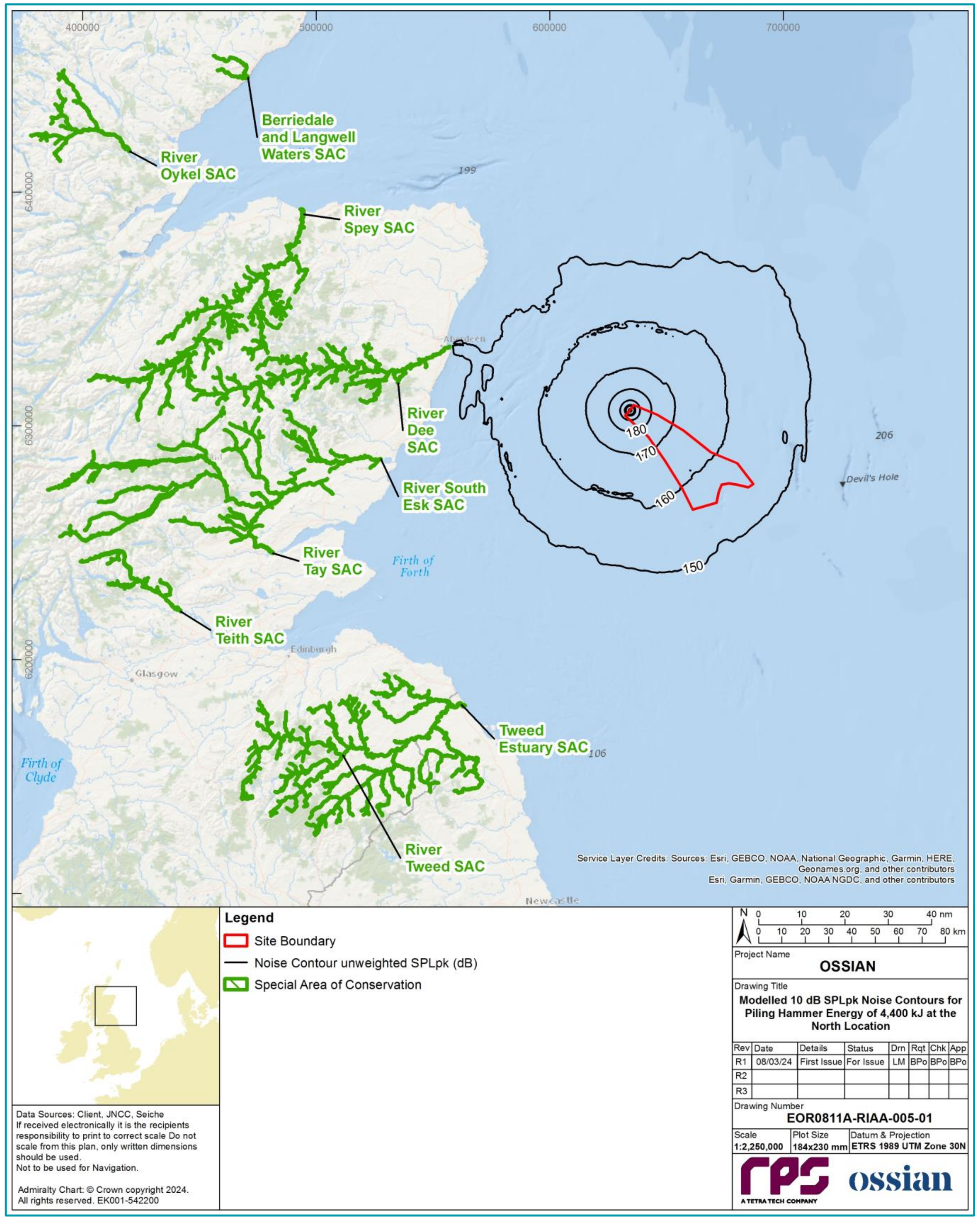


**Figure 5.2: Modelled 10 dB SPL$_{pk}$ Noise Contours for Piling Hammer Energy of 4,400 kJ at the North Location**

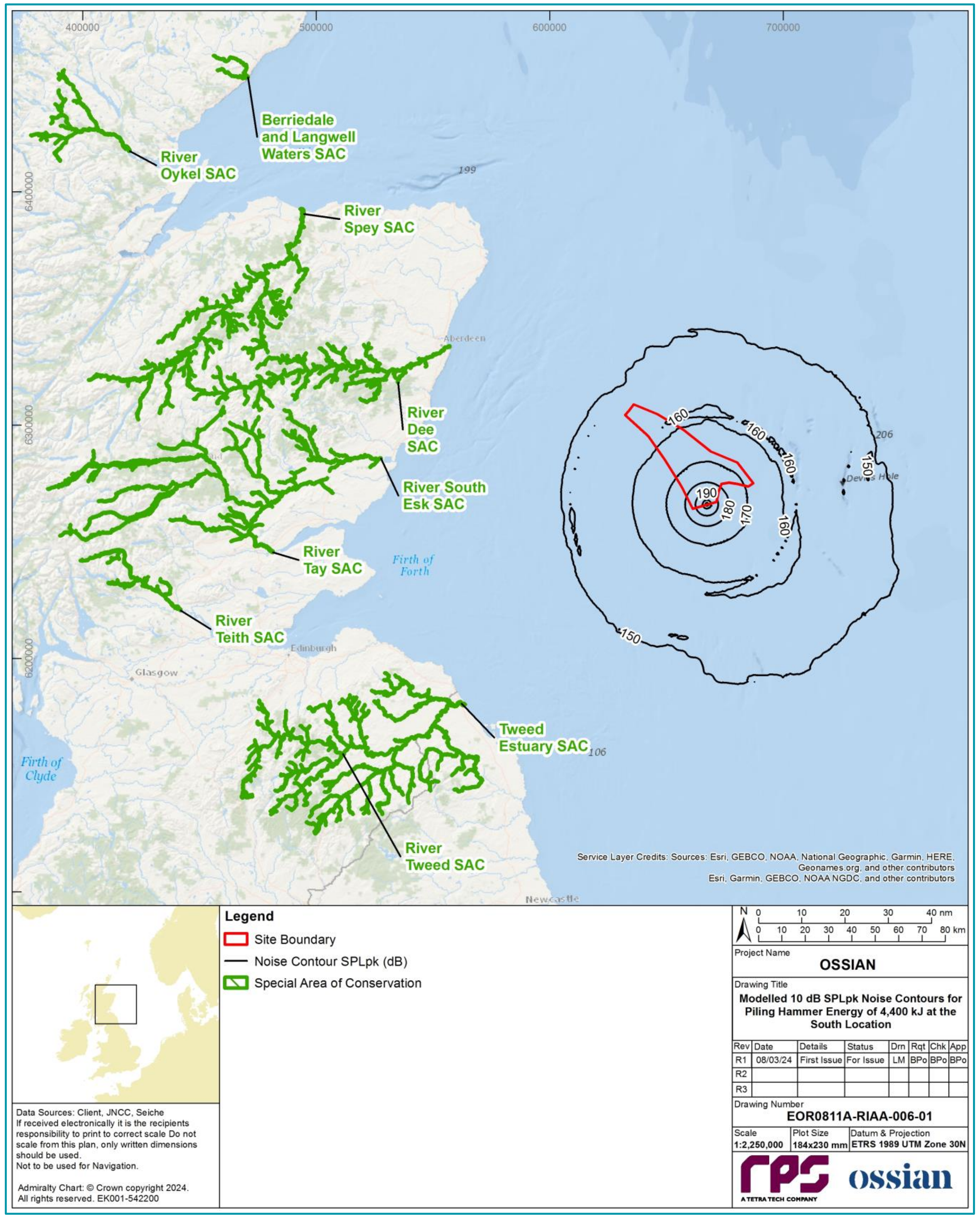


**Figure 5.3: Modelled 10 dB $SPL_{pk}$ Noise Contours for Piling Hammer Energy of 4,400 kJ at the South Location**

<u>Summary of underwater noise modelling</u>

186. Sea lamprey and Atlantic salmon close to piling operations may experience injury or mortality. However, diadromous fish species tend to be highly mobile and are unlikely to be particularly reliant on the marine environment within the fish and shellfish ecology study area other than to pass through during migration. Therefore, piling is unlikely to result in significant mortality of Annex II diadromous species. The use of soft start piling procedures (see Table 5.4) will allow many individuals in close proximity to piling to flee the ensonified area and will also reduce the overall acoustic energy entering the marine environment, therefore reducing the likelihood of injury and mortality.

187. Atlantic salmon and sea lamprey may experience behavioural effects in response to piling noise, including a startle response, disruption of feeding, or avoidance of an area. As discussed in paragraphs 176 *et seq.,* these would be expected to occur at ranges up to low tens of kilometres, depending on the maximum hammer energies. Due to the distance of the site boundary from the Scottish coast (approximately 80 km), potential behavioural impacts are highly unlikely to cause barrier effects to diadromous species as they migrate along the east coast of Scotland, due to the relatively limited area around piling events where noise levels are high enough to cause behavioural responses (as demonstrated in Figure 5.2 and Figure 5.3).

## Construction phase

<u>River Dee SAC</u>

### Atlantic salmon

188. As outlined in paragraphs 163 to 175, Atlantic salmon within close proximity to piling operations may experience injury or mortality due to underwater noise from piling or UXO clearance. However, Atlantic salmon are highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that at-sea behaviour is largely unknown). Therefore, it is unlikely that this impact will result in significant mortality or injury to the Atlantic salmon feature of this SAC. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow individuals in close proximity to piling to move away from the ensonified area and reduce the total amount of acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

189. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these may occur out to a range in the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

### Freshwater pearl mussel

190. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraphs 188 to 189, underwater noise in the construction phase will not lead to significant mortality or

injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Conclusion**

191. Adverse effects on the qualifying Annex II diadromous fish features of the River Dee SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise during construction activities. Potential effects from these activities on the relevant conservation objectives (as presented in paragraphs 69 to 71) are discussed in turn below in Table 5.14.

**Table 5.14: Conclusions Against the Conservation Objectives of the River Dee SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020c) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. This impact will not prevent the population, distribution, nor genetic diversity of Atlantic salmon within the site from being restored.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array, but the underwater noise modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this impact will not prevent the populations, the distributions, nor genetic diversity of Atlantic salmon from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats and availability of food that support Atlantic salmon within the site. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with underwater noise and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that underwater noise will not indirectly prevent the population from being a viable component of the site or prevent the distribution freshwater pearl mussel within the site from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between underwater noise generated during the construction phase and the habitats and availability of food that support freshwater pearl mussel. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

192. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Dee SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phase of the Array alone.

<u>River South Esk SAC</u>

**Atlantic salmon**

193. As outlined in paragraphs 163 to 175, Atlantic salmon within close proximity to piling operations may experience injury or mortality due to underwater noise from piling or UXO clearance. However, Atlantic salmon are highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that at-sea behaviour is largely unknown). Therefore, it is unlikely that this impact will result in significant mortality or injury to the Atlantic salmon feature of this SAC. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow individuals in close proximity to piling to move away from the ensonified area and reduce the total amount of acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

194. As outlined in paragraphs 176 *et seq.*, underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these may occur out to a range in the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Freshwater pearl mussel**

195. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraphs 193 and 194, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

### Conclusion

196. Adverse effects on the qualifying Annex II diadromous fish features of the River South Esk SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise during construction activities. Potential effects from these activities on the relevant conservation objectives (as presented in paragraphs 78 to 80) are discussed in turn below in Table 5.15.

**Table 5.15: Conclusions Against the Conservation Objectives of the River South Esk SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020e) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. Therefore, this potential impact will not prevent the populations of Atlantic salmon from being restored as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being restored.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this potential impact will not prevent the populations of Atlantic salmon from being restored as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats and availability of food that support Atlantic salmon within the site. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with underwater noise and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that underwater noise will not indirectly prevent the populations of freshwater pearl mussel from being a viable component of this site or the distributions of this species from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between underwater noise generated during the construction phase and the habitats and availability of food that support freshwater pearl mussel. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

197. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River South Esk SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phase of the Array alone.

<u>Tweed Estuary SAC</u>

### Sea lamprey

198. As for Atlantic salmon, the underwater noise modelling suggested that sea lamprey within close proximity to piling operations and UXO clearance may experience injury or mortality. However, sea lamprey are also highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that the at-sea behaviour and habitat use of sea lamprey is largely unknown). Therefore, this impact is unlikely to result in significant mortality or injury to sea lamprey. Further, as presented in Table 5.4, the soft start piling procedures designed in measure will allow many individuals in close proximity to piling to move away from the ensonified area and will also reduce the overall acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and the potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

199. As outlined in paragraphs 176 *et seq.*, underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these would extend out the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

### Conclusion

200. Adverse effects on the qualifying Annex II diadromous fish features of the Tweed Estuary SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise during construction activities. Potential effects from these activities on the relevant conservation objectives (as presented in paragraph 90 to 92) are discussed in turn below in Table 5.16.

**Table 5.16: Conclusions Against the Conservation Objectives of the Tweed Estuary SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (Natural England, 2018) | Conclusion |
|---|---|---|
| Sea lamprey | The extent and distribution of qualifying natural habitats and habitats of the qualifying species [are maintained or restored] | There is no pathway for impact between underwater noise generated during the construction phase and the habitats and supporting processes that support the sea lamprey feature. Therefore, this impact will not prevent the extent, distribution, structure, function, and supporting processes of the sea lamprey habitats within the site from being maintained or restored. |
| | The structure and function of the habitats of the qualifying species [are maintained or restored] | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely [are maintained or restored] | |
| | The populations of each of the qualifying species [are maintained or restored] | As detailed by the results of the underwater noise modelling, sea lamprey within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. This impact will not prevent the population and distribution of sea lamprey within the site from being maintained or restored.<br><br>Sea lamprey may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. Therefore, this impact will not prevent the populations or the distributions of sea lamprey from being maintained or restored. |
| | The distribution qualifying species within the site [are maintained or restored] | |

201. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Tweed Estuary SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phase the Array alone.

River Tweed SAC

**Atlantic salmon**

202. As outlined in paragraphs 163 to 175, Atlantic salmon within close proximity to piling operations may experience injury or mortality due to underwater noise from piling or UXO clearance. However, Atlantic salmon are highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that at-sea behaviour is largely unknown). Therefore, it is unlikely that this impact will result in significant mortality or injury to the Atlantic salmon feature of this SAC. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow individuals in close proximity to piling to move away from the ensonified area and reduce the total amount of acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

203. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these may occur out to a range in the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Sea lamprey**

204. As for Atlantic salmon, the underwater noise modelling suggested that sea lamprey within close proximity to piling operations and UXO clearance may experience injury or mortality. However, sea lamprey are also highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that the at-sea behaviour and habitat use of sea lamprey is largely unknown). Therefore, this impact is unlikely to result in significant mortality or injury to sea lamprey. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow many individuals in close proximity to piling to move away from the ensonified area and will also reduce the overall acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

205. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these would extend out the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Conclusion**

206. Adverse effects on the qualifying Annex II diadromous fish features of the River Tweed SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise during construction activities. Potential effects from these activities on the relevant conservation objectives (as presented in paragraphs 99 to 101) are discussed in turn below in Table 5.17.

**Table 5.17: Conclusions Against the Conservation Objectives of the River Tweed SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (Natural England, 2022, NatureScot, 2020h) | Conclusion |
|---|---|---|
| **NatureScot Conservation Objectives** | | |
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Maintain the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. Therefore, this impact will not prevent the populations of Atlantic salmon from being maintained as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being maintained.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this impact will not prevent the populations of Atlantic salmon from being maintained as a viable component of this site or the distributions nor genetic diversity of Atlantic salmon from being maintained. |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats and availability of food that support Atlantic salmon within the site. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site<br>2b. Maintain the distribution of the sea lamprey throughout the site | As detailed by the results of the underwater noise modelling, sea lamprey within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. Therefore, this impact will not prevent the populations of sea lamprey from being a viable component of this site or the distributions of sea lamprey from being maintained or restored.<br><br>Sea lamprey may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of sea lamprey due to behavioural disturbance. Therefore, this impact will not prevent the populations of sea lamprey from being a viable component of this site or the distributions of sea lamprey from being maintained or restored. |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats supporting sea lamprey within the site and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained or restored. |
| **Natural England Conservation Objectives** | | |
| Atlantic salmon and sea lamprey | The extent and distribution of qualifying natural habitats and habitats of qualifying species [are maintained or restored]<br>The structure and function of the habitats of qualifying species [is maintained or restored]<br>The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely [are maintained or restored] | There is no pathway for impact between underwater noise generated during the construction phase and the habitats and supporting processes that support the Atlantic salmon and sea lamprey qualifying features. Therefore, this impact will not prevent the extent, distribution, structure, function, and supporting processes of their habitats within the site from being maintained or restored. |
| | The populations of qualifying species [are maintained or restored'<br>The distribution of qualifying species within the site [are maintained or restored] | As detailed above for the NatureScot conservation objectives, this impact will not prevent the populations and distribution of the Atlantic salmon and sea lamprey qualifying features from being maintained or restored. |

207. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Tweed SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phase of the Array alone.

River Tay SAC

**Atlantic salmon**

208. As outlined in paragraphs 163 to 175, Atlantic salmon within close proximity to piling operations may experience injury or mortality due to underwater noise from piling or UXO clearance. However, Atlantic salmon are highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that at-sea behaviour is largely unknown). Therefore, it is unlikely that this impact will result in significant mortality or injury to the Atlantic salmon feature of this SAC. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow individuals in close proximity to piling to move away from the ensonified area and reduce the total amount of acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

209. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these may occur out to a range in the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Sea lamprey**

210. As for Atlantic salmon, the underwater noise modelling suggested that sea lamprey within close proximity to piling operations and UXO clearance may experience injury or mortality. However, sea lamprey are also highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that the at-sea behaviour and habitat use of sea lamprey is largely unknown). Therefore, this impact is unlikely to result in significant mortality or injury to sea lamprey. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow many individuals in close proximity to piling to move away from the ensonified area and will also reduce the overall acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

211. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these would extend out the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Conclusion**

212. Adverse effects on the qualifying Annex II diadromous fish features of the River Tay SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise during construction activities. Potential effects from these activities on the relevant conservation objectives (as presented in paragraphs 113 to 115) are discussed in turn below in Table 5.18.

**Table 5.18: Conclusions Against the Conservation Objectives of the River Tay SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020g) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Maintain the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. Therefore, this potential impact will not prevent the populations of Atlantic salmon from being maintained as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being maintained.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this potential impact will not prevent the populations of Atlantic salmon from being maintained as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being maintained. |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats and availability of food that support Atlantic salmon within the site. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site<br>2b. Maintain the distribution of the sea lamprey throughout the site | As detailed by the results of the underwater noise modelling, sea lamprey within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. Therefore, this impact will not prevent the populations of sea lamprey from being a viable component of this site or the distributions of sea lamprey from being maintained.<br><br>Sea lamprey may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of sea lamprey due to behavioural disturbance. Therefore, this impact will not prevent the populations of sea lamprey from being a viable component of this site or the distributions of sea lamprey from being maintained. |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats and availability of food that support sea lamprey within the site. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained. |

213. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Tay SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phase of the Array alone.

River Spey SAC

**Atlantic salmon**

214. As outlined in paragraphs 163 to 175, Atlantic salmon within close proximity to piling operations may experience injury or mortality due to underwater noise from piling or UXO clearance. However, Atlantic salmon are highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that at-sea behaviour is largely unknown). Therefore, it is unlikely that this impact will result in significant mortality or injury to the Atlantic salmon feature of this SAC. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow individuals in close proximity to piling to move away from the ensonified area and reduce the total amount of acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

215. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these may occur out to a range in the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Freshwater pearl mussel**

216. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraphs 214 and 215, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Sea lamprey**

217. As for Atlantic salmon, the underwater noise modelling suggested that sea lamprey within close proximity to piling operations and UXO clearance may experience injury or mortality. However, sea lamprey are also highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that the at-sea behaviour and habitat use of sea lamprey is largely unknown). Therefore, this impact is unlikely to result in significant mortality or injury to sea lamprey. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow many individuals in close proximity to piling to move away from the ensonified area and will also reduce the overall acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

218. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these would extend out the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Conclusion**

219. Adverse effects on the qualifying Annex II diadromous fish features of the River Spey SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise during construction activities. Potential effects from these activities on the relevant conservation objectives (as presented in paragraphs 123 to 126) are discussed in turn below in Table 5.19.

**Table 5.19: Conclusions Against the Conservation Objectives of the River Spey SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020f) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. Therefore, this impact will not prevent the populations of Atlantic salmon from being restored as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being restored.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this impact will not prevent the populations of Atlantic salmon from being restored as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support Atlantic salmon within the site and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with underwater noise and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that underwater noise will not indirectly prevent the populations of freshwater pearl mussel from being a viable component of this site or the distributions of this species from being restored |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between underwater noise generated during the construction phase and the habitats and availability of food that support freshwater pearl mussel. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site<br>2b. Maintain the distribution of the sea lamprey throughout the site | As detailed by the results of the underwater noise modelling, sea lamprey within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. Therefore, this impact will not prevent the populations of sea lamprey from being a viable component of this site or the distributions of sea lamprey from being maintained.<br><br>Sea lamprey may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of sea lamprey due to behavioural disturbance. Therefore, this impact will not prevent the populations of sea lamprey from being a viable component of this site or the distributions of sea lamprey from being maintained. |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support sea lamprey within the site and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained. |

220. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Spey SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phase of the Array alone.

Berriedale and Langwell Waters SAC

**Atlantic salmon**

221. As outlined in paragraphs 163 to 175, Atlantic salmon within close proximity to piling operations may experience injury or mortality due to underwater noise from piling or UXO clearance. However, Atlantic salmon are highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that at-sea behaviour is largely unknown). Therefore, it is unlikely that this impact will result in significant mortality or injury to the Atlantic salmon feature of this SAC. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow individuals in close proximity to piling to move away from the ensonified area and reduce the total amount of acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

222. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these may occur out to a range in the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Conclusion**

223. Adverse effects on the qualifying Annex II diadromous fish features of the Berriedale and Langwell Waters SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise during construction activities. Potential effects from these activities on the relevant conservation objectives (as presented in paragraph 133) are discussed in turn below in Table 5.20.

**Table 5.20: Conclusions Against the Conservation Objectives of the Berriedale and Langwell Waters SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020b) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Maintain the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. Therefore, this impact will not prevent the populations of Atlantic salmon from being maintained as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being maintained.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this impact will not prevent the populations of Atlantic salmon from being maintained as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being maintained. |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support Atlantic salmon within the site and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained. |

224. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berriedale and Langwell Waters SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phase of the Array alone.

River Teith SAC

**Atlantic salmon**

225. As outlined in paragraphs 163 to 175, Atlantic salmon within close proximity to piling operations may experience injury or mortality due to underwater noise from piling or UXO clearance. However, Atlantic salmon are highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that at-sea behaviour is largely unknown). Therefore, it is unlikely that this impact will result in significant mortality or injury to the Atlantic salmon feature of this SAC. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow individuals in close proximity to piling to move away from the ensonified area and reduce the total amount of acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the

noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

226. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these may occur out to a range in the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Sea lamprey**

227. As for Atlantic salmon, the underwater noise modelling suggested that sea lamprey within close proximity to piling operations and UXO clearance may experience injury or mortality. However, sea lamprey are also highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that the at-sea behaviour and habitat use of sea lamprey is largely unknown). Therefore, this impact is unlikely to result in significant mortality or injury to sea lamprey. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow many individuals in close proximity to piling to move away from the ensonified area and will also reduce the overall acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

228. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these would extend out the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Conclusion**

229. Adverse effects on the qualifying Annex II diadromous fish features of the River Teith SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise during construction activities. Potential effects from these activities on the relevant conservation objectives (as presented in paragraphs 140 to 141) are discussed in turn below in Table 5.21. As stated in paragraphs 140 to 141), a CAP has not yet been published for the River Teith SAC, and therefore, only the overarching conservation objectives for all qualifying species features are presented in Table 5.21 for Atlantic salmon and sea lamprey combined. The assessment has therefore been undertaken with regard to the available conservation objectives for the site (NatureScot, 2015).

**Table 5.21: Conclusions Against the Conservation Objectives of the River Teith SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (JNCC, 2015) | Conclusion |
|---|---|---|
| Atlantic salmon and sea lamprey | The population of the species, including range of genetic types for Atlantic salmon, as a viable component of the site is maintained in the long term<br>The distribution of the species within the site is maintained in the long term | As detailed by the results of the underwater noise modelling, Atlantic salmon and sea lamprey within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. This impact will not prevent the populations of each species from being maintained as viable components of the site or the distribution nor genetic diversity of these species within the site from being maintained in the long term.<br><br>Atlantic salmon and sea lamprey may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon and sea lamprey due to behavioural disturbance. Therefore, this impact will not prevent the populations of each species from being maintained as viable components of the site or the distribution nor genetic diversity of these species within the site from being maintained in the long term. |
| | The distribution and extent of habitats supporting the species is maintained in the long term<br>The structure, function and supporting processes of habitats supporting the species is maintained in the long term | There is no pathway for impact between underwater noise generated during the construction phase and the distribution, extent, structure, function, and supporting processes of the habitats that support Atlantic salmon and sea lamprey. Therefore, this impact will not prevent these aspects of Atlantic salmon and sea lamprey habitats from being maintained in the long term. |
| | There is no significant disturbance of the species | As stated in the rows above for the populations and distributions of Atlantic salmon and sea lamprey, there is negligible risk to these species in terms of behavioural disturbance caused by underwater noise. Therefore, this impact will not cause significant disturbance of Atlantic salmon and sea lamprey. |

230. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Teith SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phase of the Array alone.

River Oykel SAC

**Atlantic salmon**

231. As outlined in paragraphs 163 to 175, Atlantic salmon within close proximity to piling operations may experience injury or mortality due to underwater noise from piling or UXO clearance. However, Atlantic salmon are highly mobile, and may only use the fish and shellfish ecology study area to pass through during migration (noting that at-sea behaviour is largely unknown). Therefore, it is unlikely that this impact will result in significant mortality or injury to the Atlantic salmon feature of this SAC. Further, as presented in Table 5.4, the designed in measure of soft start piling procedures will allow individuals in close proximity to piling to move away from the ensonified area and reduce the total amount of acoustic energy entering the marine environment. In addition, the designed in measure of low order UXO disposal will reduce the noise levels and their potential for injury in the vicinity of UXO clearance operations. Overall, these two designed in measures further reduce the likelihood of injury and mortality.

232. As outlined in paragraphs 176 *et seq.,* underwater noise during piling would result in behavioural responses in the vicinity of the Array, although these may occur out to a range in the low tens of kilometres, and thus not represent a significant barrier to migration to and from the SAC, particularly in terms of the vast availability of habitat in the North Sea and distance between the coast and the site boundary (Figure 5.2 and Figure 5.3). The behavioural disturbance modelling results are also highly precautionary as they were modelled against the maximum hammer energy, which will not realistically occur over the duration of the piling programme. Further, the potential underwater noise impacts will be short term and intermittent in nature during the construction phase (i.e. piling occurring over up to 602 days over eight years). As such, there is negligible risk of disruption to migration.

**Freshwater pearl mussel**

233. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraphs 231 and 232, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Conclusion**

234. Adverse effects on the qualifying Annex II diadromous fish features of the River Oykel SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise during construction activities. Potential effects from these activities on the relevant conservation objectives (as presented in paragraphs 146 to 148) are discussed in turn below in Table 5.22.

**Table 5.22: Conclusions Against the Conservation Objectives of the River Oykel SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020d) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. However, they are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. Therefore, this impact will not prevent the populations of Atlantic salmon from being restored as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being restored.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array, but the modelling indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this impact will not prevent the populations of Atlantic salmon from being restored as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support Atlantic salmon within the site and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the sit3 | As a freshwater resident species, there is no direct pathway for impact associated with underwater noise and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that underwater noise will not indirectly prevent the populations of freshwater pearl mussel from being a viable component of this site or the distributions of this species from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between underwater noise generated during the construction phase and the habitats and availability of food that support freshwater pearl mussel. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

235. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Oykel SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phase of the Array alone.

### 5.3.2. EFFECTS DUE TO EMFS FROM SUBSEA ELECTRICAL CABLING

236. The LSE[2] assessment during the HRA Stage One process identified that during the operation and maintenance phase, LSE[2] could not be ruled out for potential effects to Annex II diadromous fish from EMFs generated by subsea electrical cables. This relates to the following sites and relevant Annex II diadromous fish features:

- River Dee SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.
- River South Esk SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.
- Tweed Estuary SAC;
  - sea lamprey.
- River Tweed SAC;
  - Atlantic salmon; and
  - sea lamprey.
- River Tay SAC;
  - Atlantic salmon; and
  - sea lamprey.
- River Spey SAC;
  - Atlantic salmon;
  - freshwater pearl mussel; and
  - sea lamprey.
- Berriedale and Langwell Waters SAC;
  - Atlantic salmon.
- River Teith SAC; and
  - Atlantic salmon; and
  - sea lamprey.
- River Oykel SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.

237. The MDS considered for the assessment of EMF is shown in Table 5.23. There are no designed in measures for the Array applicable to this impact.

**Table 5.23: MDS Considered for the Assessment of Potential Impacts to Annex II Diadromous Fish due to EMFs during the Operation and Maintenance Phase of the Array Alone**

| Project Phase | MDS | Justification |
|---|---|---|
| Operation and maintenance | Presence of inter-array and interconnector cables:<br>• up to 1,261 km of 66 kV or 132 kV inter-array cables with maximum 116 km in the water column, with the rest buried to a minimum target depth of 0.4 m (subject to a Cable Burial Risk Assessment (CBRA));<br>• up to 236 km of 275 kV Alternating Current (AC) or 525 kV Direct Current (DC) interconnector cables with the total length buried to a minimum target burial depth of 0.4 m (subject to a CBRA);<br>• up to 20% of inter-array and interconnector cables may require cable protection;<br>• cables will also require cable protection at asset crossings (up to 12 crossings for inter-array cables and up to 12 crossings for interconnector cables); and<br>• up to 228 junction boxes will be required for inter-array cables.<br><br>The operation and maintenance phase will be up to 35 years. | The MDS for this impact is based on the greatest cable length proposed, both in the water column and buried in the seabed. |

#### Information to support the assessment

Background information on EMFs

238. Effects to Annex II diadromous fish may arise due to EMFs generated from the subsea electrical cables associated with the Array as outlined in Table 5.23. The conduction of electricity through subsea power cables will result in emission of localised EMFs which could potentially affect the sensory mechanisms of diadromous fish species (Centre for Marine and Coastal Studies (CMACS (2003)). This assessment also considers the impacts of EMFs from the dynamic inter-array cables in the water column (Table 5.23).

239. EMFs comprise both the electrical fields, measured in volts per metre (V/m), and the magnetic fields, measured in microtesla (µT), millitesla (mT), milligauss (mG) or gauss. Within the North Sea, background magnetic field measurements are approximately 50 µT, and background electric field measurements are approximately 25 µV/m (Tasker *et al.*, 2010). Subsea cables are constructed using magnetic outer sheathing materials, which can partially block the direct electrical field (E-field), meaning that the only EMFs that are emitted into the marine environment are the magnetic field (B-field) and the resultant induced electrical field (iE-field). Dynamic cables are typically double armoured to increase stability and manage weight, which may inadvertently reduce losses of EMFs (Hervé, 2021). By design, AC and DC cables typically contain three and two conductor bundles, respectively, which are superimposed and twisted around each other. This design feature creates partial self-cancellation of the total B-field (CSA Ocean Sciences Inc and Exponent, 2019, Hervé, 2021).

240. The strength of the B-field (and consequently, induced E-fields) decreases rapidly horizontally and vertically with distance from source. At the seabed, cable burial and cable protection are common industry practice measures, which can reduce EMF levels at the seabed surface as a result of field decay with distance of the seabed from the cable (Chapman *et al.*, 2023, CSA Ocean Sciences Inc and Exponent, 2019, Gill *et al.*, 2005, Gill *et al.*, 2009). For example, a recent study by CSA Ocean Sciences Inc and Exponent (2019) found that inter-array and offshore export cables buried between depths of 1 m to 2 m

reduced the B-field at the seabed surface four-fold. For cables that were unburied and instead protected by thick concrete mattresses or rock berms, the field levels were found to be similar to those of buried cables (CSA Ocean Sciences Inc and Exponent, 2019). The same study also demonstrated that B-field levels directly over live AC inter-array cables associated with offshore wind projects ranged between 65 mG at the seabed and 5 mG and 1 m above the seabed. At lateral distances from the cables, B-fields greatly reduced at the sea floor to between 10 mG and <0.1 mG (CSA Ocean Sciences Inc and Exponent, 2019).

241. Clear differences between AC and DC systems are also apparent. The flow of electricity associated with an AC cable changes direction (as per the frequency of the AC transmission) and creates a constantly varying E-field in the surrounding marine environment (ElectroMagneticWorks Inc, 2022, Huang, 2005). Conversely, DC cables transmit energy in one direction creating a static E-field and B-field. Average B- fields of DC cables are also higher than those of equivalent AC cables (ElectroMagneticWorks Inc, 2022, Huang, 2005).

242. Overall, EMF levels in the vicinity of subsea cables are influenced by a variety of design and installation factors, including distance between cables, cable sheathing, number of conductors, and internal cable configuration.

243. While the majority of cables will be buried beneath surface sediments to a minimum burial depth of 0.4 m, up to 116 km will be dynamic cables within the water column (Table 5.23). However, the intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al.*, 2021). This attenuation is the same for buried, unburied, and dynamic cables (Hutchison *et al.*, 2021). So, whilst EMFs from dynamic cables will be considerably higher than compared to buried cables (i.e. due to the lack of surface sediments/protection upon these), EMF levels will return to the baseline level within a few metres distance from the cable, to a maximum of a few tens of metres. Therefore, as for the buried cables at the seabed, the area of effect is highly limited in extent, particularly in the context of the fish and shellfish ecology study area as a whole and wider migration route of diadromous fish species.

Sensitivity of Annex II diadromous fish species to EMFs

244. EMFs may interfere with the navigational ability of some diadromous fish species. Species for which there is evidence of a response to E and/or B-fields include Atlantic salmon, sea lamprey, river lamprey, and European eel *Anguilla anguilla* (CSA Ocean Sciences Inc and Exponent, 2019, Gill *et al.*, 2005). During the marine phase of their life cycles, diadromous fish species may be exposed to EMFs from the dynamic cables in the water column. EMFs emitted from these dynamic cables are likely to only be detected within a matter of metres; beyond which, baseline levels will be established (see paragraph 243). As such, impacts from EMFs from the dynamic cables are highly localised. Lamprey species possess specialised ampullary electroreceptors that are sensitive to weak, low frequency electric fields (Bodznick *et al.*, 1981, Bodznick *et al.*, 1983), which are hypothesised to be used for prey-detection, although further research is required in this area (Tricas *et al.*, 2012). Chung-Davidson *et al.* (2008) found that weak electric fields may play a role in the reproduction of sea lamprey and it was suggested that electrical stimuli mediate different behaviours in feeding-stage and spawning-stage individuals. This study showed that migration behaviour of sea lamprey was affected (i.e. adults did not move) when stimulated with electrical fields of intensities of between 2.5 mV/m and 100 mV/m, with normal behaviour observed at electrical field intensities higher and lower than this range (Chung-Davidson *et al.*, 2008). It should be noted, however, that these levels are considerably higher than modelled induced electrical fields expected from AC subsea cables. There is currently no evidence of lamprey responses to B-fields (Gill *et al.*, 2010).

245. Salmonids (including Atlantic salmon) have been found to possess magnetic material of a size suitable for magnetoreception, and can use the earth's magnetic field for orientation and direction-finding during migration (CSA Ocean Sciences Inc and Exponent, 2019, Gill *et al.*, 2010). Research in Sweden on the effects of a High Voltage Direct Current (HVDC) cable on the migration patterns of a range of fish species, including salmonids, failed to find any effect (Westerberg *et al.*, 2007, Wilhelmsson *et al.*, 2010). Research conducted at the Trans Bay cable, a DC undersea cable near San Francisco, California, found that migration success and survival of chinook salmon *Oncorhynchus tshawytscha* was not impacted by the cable (Kavet *et al.*, 2016). However, behavioural changes were noted when these salmonids were near the cable with individuals appearing to remain around the cable for longer periods (Kavet *et al.*, 2016). Similarly, Yano *et al.* (1997) investigated the role of magnetic compass orientation in oceanic migrating chum salmon, *Oncorhynchus keta*, off the coast of Japan. Four chum salmon were fitted with a tag which generated an artificial B-field which produced an alternating intensity of around 6 gauss, with polarity which reversed every 11.25 minutes. The authors did not observe any effects on horizontal or vertical movements of the chum salmon when the B-field was modified (Yano *et al.*, 1997). Further, the effects of mains frequency (50 Hz) B-fields on behaviour of captive Atlantic salmon were investigated by Armstrong *et al.* (2015). They found that large Atlantic salmon (62 cm to 85 cm) demonstrated no significant differences in approach, traverse or departure times associated with coils emitting a B-field of 95 µT. Post-smolts (24 cm to 41 cm in size) were exposed to three 30 minute periods of B-fields at 1.3, 11.4 and 95 µT with 30 minutes of control conditions before each treatment. There was no evidence that the numbers of post-smolts passing through the coils depended on the sequence of intensity of the B-fields. There were also no observations of unusual behaviours in association with B-fields up to 95 µT (Armstrong *et al.*, 2015). During their marine phase, Atlantic salmon are thought to use chemoreceptors in coastal waters to locate their natal river and EMFs during offshore migrations (Gill *et al.*, 2010). However, as Atlantic salmon are a pelagic species, the effects would be mostly perceived in shallower waters (Snyder *et al.*, 2019).

246. Although not an Annex II species, European eel have also been suggested to use the earth's magnetic field for navigational purposes during migration (CSA Ocean Sciences Inc and Exponent, 2019, Gill *et al.*, 2010). Studies on European eel have highlighted some limited effects of subsea cables (Westerberg *et al.*, 2008), with evidence of direct detection of EMF through its lateral line (Moore *et al.*, 2009). Westerberg *et al.* (2008) demonstrated short term changes in European eel swimming speed during migration (i.e. tens of minutes) due to exposure to AC electric subsea cables, even though the overall direction remained unaffected. Ohman *et al.* (2007) concluded that any delaying effect (i.e. on average 40 minutes) were not likely to impact fitness over the species' 7,000 km migration, with little to no impact on migratory behaviour noted beyond 500 m from wind farm development infrastructure. While the research summarised in this paragraph does not focus on the Annex II diadromous fish features of the SACs assessed in this Part of the RIAA, it indicates that behavioural effects in response to EMF are limited both temporally and spatially and do not cause barriers to migration for European eel. Reasonably, these assumptions can also be inferred to Atlantic salmon and sea lamprey.

247. These studies demonstrate that while EMFs can result in altered patterns of fish behaviour, these changes are temporary and highly localised, and are therefore not likely to represent barriers to migration or impede population health. It should be noted that although there is limited information available in the literature on the impacts and sensitivities of shellfish species to EMFs, Annex II freshwater pearl mussel would not be directly impacted by EMFs produced by electrical cabling associated with the Array given that they are a freshwater resident species. There will be no electrical cabling associated with the Array installed in any freshwater habitats, as the Array is solely located within offshore waters.

### Operation and maintenance phase

River Dee SAC

**Atlantic salmon**

248. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of Atlantic salmon and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, Atlantic salmon and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

249. Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from

the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Freshwater pearl mussel**

250. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraphs 248 and 249, EMFs from subsea electrical cabling in the operation and maintenance phase are unlikely to result in barriers to migration for Atlantic salmon. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Conclusion**

251. Adverse effects on the qualifying Annex II diadromous fish features of the River Dee SAC which undermine the conservation objectives of the SAC will not occur as a result of EMFs from subsea electrical cabling during the operation and maintenance phase. Potential effects from this impact on the relevant conservation objectives (as presented in paragraphs 69 to 71) are discussed in turn below in Table 5.24.

**Table 5.24: Conclusions Against the Conservation Objectives of the River Dee SAC from EMFs from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020c) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for Atlantic salmon, and this impact will not prevent the populations of Atlantic salmon from being restored as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with EMFs from subsea electrical cabling associated with the Array and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, EMFs will not lead to barriers to migration. Therefore, it can also be concluded that this impact will not indirectly prevent the populations of freshwater pearl mussel from being a viable component of this site or the distributions of this species from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between EMFs from subsea electrical cabling and the habitats that support freshwater pearl mussel and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

252. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Dee SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phase of the Array alone.

River South Esk SAC

**Atlantic salmon**

253. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of Atlantic salmon and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, Atlantic salmon and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

254. Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Freshwater pearl mussel**

255. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraphs 253 and 254, EMFs from subsea electrical cabling in the operation and maintenance phase are unlikely to result in barriers to migration for Atlantic salmon. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Conclusion**

256. Adverse effects on the qualifying Annex II diadromous fish features of the River South Esk SAC which undermine the conservation objectives of the SAC will not occur as a result of EMFs from subsea electrical cabling during the operation and maintenance phase. Potential effects from this impact on the relevant conservation objectives (as presented in paragraphs 78 to 80) are discussed in turn below in Table 5.25.

**Table 5.25: Conclusions Against the Conservation Objectives of the River South Esk SAC from EMFs from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020e) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for Atlantic salmon, and this impact will not prevent the populations of Atlantic salmon from being restored as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with EMFs from subsea electrical cabling associated with the Array and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, EMFs will not lead to barriers to migration. Therefore, it can also be concluded that this impact will not indirectly prevent the populations of freshwater pearl mussel from being a viable component of this site or the distributions of this species from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between EMFs from subsea electrical cabling and the habitats that support freshwater pearl mussel and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

257. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River South Esk SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phase of the Array alone.

Tweed Estuary SAC

**Sea lamprey**

258. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of sea lamprey and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, sea lamprey and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

259. Sea lamprey are considered to have significantly reduced sensitivity to EMFs in comparison with other fish species, such as elasmobranchs (Gill *et al.*, 2005, Hutchison *et al.*, 2018). Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

Conclusion

260. Adverse effects on the qualifying Annex II diadromous fish features of the Tweed Estuary SAC which undermine the conservation objectives of the SAC will not occur as a result of EMFs from subsea electrical cabling during the operation and maintenance phase. Potential effects from this impact on the relevant conservation objectives (as presented in paragraph 90) are discussed in turn below in Table 5.26.

**Table 5.26: Conclusions Against the Conservation Objectives of the Tweed Estuary SAC from EMFs from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (Natural England, 2018) | Conclusion |
|---|---|---|
| Sea lamprey | The extent and distribution of qualifying natural habitats and habitats of the qualifying species [are maintained or restored] | There is no pathway for impact between EMFs from subsea electrical cabling and the habitats and supporting processes that support the sea lamprey feature. Therefore, this impact will not prevent the extent, distribution, structure, function, and supporting processes of the sea lamprey habitats within the site from being maintained or restored. |
| | The structure and function of the habitats of the qualifying species [are maintained or restored] | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely [are maintained or restored] | |
| | The populations of each of the qualifying species [are maintained or restored] | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for sea lamprey, and this impact will not prevent the population and distribution of sea lamprey within the site from being maintained or restored. |
| | The distribution qualifying species within the site [are maintained or restored] | |

261. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Tweed Estuary SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phase of the Array alone.

River Tweed SAC

**Atlantic salmon**

262. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of Atlantic salmon and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, Atlantic salmon and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

263. Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Sea lamprey**

264. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of sea lamprey and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, sea lamprey and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

265. Sea lamprey are considered to have significantly reduced sensitivity to EMFs in comparison with other fish species, such as elasmobranchs (Gill *et al.*, 2005, Hutchison *et al.*, 2018). Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

Conclusion

266. Adverse effects on the qualifying Annex II diadromous fish features of the River Tweed SAC which undermine the conservation objectives of the SAC will not occur as a result of EMFs from subsea electrical cabling during the operation and maintenance phase. Potential effects from this impact on the relevant conservation objectives (as presented in paragraphs 97 to 101) are discussed in turn below in Table 5.27.

**Table 5.27: Conclusions Against the Conservation Objectives of the River Tweed SAC from EMFs from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (Natural England, 2022, NatureScot, 2020h) | Conclusion |
|---|---|---|
| **NatureScot Conservation Objectives** | | |
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for Atlantic salmon, and this impact will not prevent the populations of Atlantic salmon from being maintained as a viable component of this site or the distributions or genetic diversity of Atlantic salmon from being maintained. |
| | 2b. Maintain the distribution of Atlantic salmon throughout the site | |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for sea lamprey, and this impact will not prevent the populations of sea lamprey from being a viable component of this site or the distributions of sea lamprey from being maintained or restored. |
| | 2b. Maintain the distribution of the sea lamprey throughout the site | |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support sea lamprey within the SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained or restored. |
| **Natural England Conservation Objectives** | | |
| Atlantic salmon and sea lamprey | The extent and distribution of qualifying natural habitats and habitats of qualifying species [is maintained or restored] | There is no pathway for impact between EMFs from subsea electrical cabling and the habitats and supporting processes that support the Atlantic salmon and sea lamprey qualifying features. Therefore, this impact will not prevent the extent, distribution, structure, function, and supporting processes of their habitats within the site from being maintained or restored. |
| | The structure and function of the habitats of qualifying species [is maintained or restored] | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely [are maintained or restored] | |
| | The populations of qualifying species [are maintained or restored' | As detailed above for the NatureScot conservation objectives, this impact will not prevent the populations and distribution of the Atlantic salmon and sea lamprey qualifying features from being maintained or restored. |
| | The distribution of qualifying species within the site [are maintained or restored] | |

267. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Tweed SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phase of the Array alone.

River Tay SAC

**Atlantic salmon**

268. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of Atlantic salmon and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, Atlantic salmon and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

269. Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Sea lamprey**

270. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of sea lamprey and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, sea lamprey and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

271. Sea lamprey are considered to have significantly reduced sensitivity to EMFs in comparison with other fish species, such as elasmobranchs (Gill *et al.*, 2005, Hutchison *et al.*, 2018). Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Conclusion**

272. Adverse effects on the qualifying Annex II diadromous fish features of the River Tay SAC which undermine the conservation objectives of the SAC will not occur as a result of subsea electrical cabling during the operation and maintenance phase. Potential effects from this impact on the relevant conservation objectives (as presented in paragraphs 113 to 115) are discussed in turn below in Table 5.28.

**Table 5.28: Conclusions Against the Conservation Objectives of the River Tay SAC from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020g) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Maintain the distribution of Atlantic salmon throughout the site | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for Atlantic salmon, and this impact will not prevent the populations of this species from being a viable component of this site or the distributions or genetic diversity of this species from being maintained. |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site<br>2b. Maintain the distribution of the sea lamprey throughout the site | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for sea lamprey, and this impact will not prevent the populations of this species from being a viable component of this site or the distributions of this species from being maintained. |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support sea lamprey within the SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained. |

273. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Tay SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phase of the Array alone.

River Spey SAC

**Atlantic salmon**

274. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of Atlantic salmon and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, Atlantic salmon and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

275. Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to

within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Freshwater pearl mussel**

276. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraphs 274 and 275, EMFs from subsea electrical cabling in the operation and maintenance phase are unlikely to result in barriers to migration for Atlantic salmon. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Sea lamprey**

277. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of sea lamprey and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, sea lamprey and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

278. Sea lamprey are considered to have significantly reduced sensitivity to EMFs in comparison with other fish species, such as elasmobranchs (Gill *et al.*, 2005, Hutchison *et al.*, 2018). Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Conclusion**

279. Adverse effects on the qualifying Annex II diadromous fish features of the River Spey SAC which undermine the conservation objectives of the SAC will not occur a result of subsea electrical cabling during the operation and maintenance phase. Potential effects from this impact on the relevant conservation objectives (as presented in paragraphs 123 to 126) are discussed in turn below in Table 5.29.

**Table 5.29: Conclusions Against the Conservation Objectives of the River Spey SAC from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020f) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for Atlantic salmon, and this impact will not prevent the populations of this species from being a viable component of this site or the distributions nor genetic diversity of this species from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with EMFs from subsea electrical cabling associated with the Array and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, EMFs will not lead to barriers to migration. Therefore, it can also be concluded that this impact will not indirectly prevent the populations of this species from being a viable component of this site or the distributions of this species from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between EMFs from subsea electrical cabling and the habitats that support freshwater pearl mussel and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site<br>2b. Maintain the distribution of the sea lamprey throughout the site | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for sea lamprey, and this impact will not prevent the populations of this species from being a viable component of this site or the distributions of this species from being maintained. |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support sea lamprey within the SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained. |

280. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Spey SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phase of the Array alone.

<u>Berriedale and Langwell Waters SAC</u>

**Atlantic salmon**

281. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of Atlantic salmon and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration

routes to and from natal rivers. However, Atlantic salmon and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

282. Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Conclusion**

283. Adverse effects on the qualifying Annex II diadromous fish features of the Berriedale and Langwell Waters SAC which undermine the conservation objectives of the SAC will not occur a result of subsea electrical cabling during the operation and maintenance phase. Potential effects from this impact on the relevant conservation objectives (as presented in paragraph 133) are discussed in turn below in Table 5.30.

**Table 5.30: Conclusions Against the Conservation Objectives of the Berriedale and Langwell Waters SAC from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020b) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Maintain the distribution of Atlantic salmon throughout the site | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for Atlantic salmon, and this impact will not prevent the populations of this species from being a viable component of this site or the distributions or genetic diversity of this species from being maintained. |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability food. Therefore, this impact will not prevent the habitats within the site and availability of food from being maintained. |

284. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berriedale and Langwell Waters SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phase of the Array alone.

<u>River Teith SAC</u>

**Atlantic salmon**

285. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of Atlantic salmon and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, Atlantic salmon and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

286. Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Sea lamprey**

287. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of sea lamprey and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, sea lamprey and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

288. Sea lamprey are considered to have significantly reduced sensitivity to EMFs in comparison with other fish species, such as elasmobranchs (Gill *et al.*, 2005, Hutchison *et al.*, 2018). Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Conclusion**

289. Adverse effects on the qualifying Annex II diadromous fish features of the River Teith SAC which undermine the conservation objectives of the SAC will not occur as a result of EMFs from subsea electrical cabling in the operation and maintenance phase. Potential effects from this impact on the relevant conservation objectives (as presented in paragraph 140) are discussed in turn in Table 5.31. As stated in paragraph 140, a CAP has not yet been published for the River Teith SAC, and therefore, only the overarching conservation objectives for all qualifying species features are presented in Table 5.31 for Atlantic salmon and sea lamprey combined. The assessment has therefore been undertaken with regard to the available conservation objectives for the site (NatureScot, 2015).

**Table 5.31: Conclusions Against the Conservation Objectives of the River Teith SAC from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (JNCC, 2015) | Conclusion |
|---|---|---|
| Atlantic salmon and sea lamprey | The population of the species, including range of genetic types for Atlantic salmon, as a viable component of the site is maintained in the long term<br>The distribution of the species within the site is maintained in the long term | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for Atlantic salmon and sea lamprey, and this impact will not prevent the populations of these species from being viable components of this site or the distributions or genetic diversity of these species from being maintained in the long term. |
| | The distribution and extent of habitats supporting the species is maintained in the long term<br>The structure, function and supporting processes of habitats supporting the species is maintained in the long term | There is no pathway for impact between EMFs from subsea electrical cabling and the distribution, extent, structure, function, and supporting processes of the habitats that support Atlantic salmon and sea lamprey. Therefore, this impact will not prevent these aspects of Atlantic salmon and sea lamprey habitats from being maintained in the long term. |
| | There is no significant disturbance of the species | As any potential behavioural effects from EMFs will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. Therefore, this impact will not cause significant disturbance of Atlantic salmon and sea lamprey. |

290. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Teith SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phase of the Array alone.

River Oykel SAC

**Atlantic salmon**

291. As outlined in paragraphs 244 to 247, EMF may influence the behaviour of Atlantic salmon and other diadromous fish. These effects may be detrimental if they result in the creation of a barrier to migration routes to and from natal rivers. However, Atlantic salmon and other diadromous fish are highly mobile and are considered to be capable of changing course during migration between natal rivers and the open sea.

292. Further, as detailed in paragraphs 238 to 243, EMFs produced from buried and dynamic cables will attenuate to baseline levels within a few metres to few tens of metres (both horizontally and vertically) from the cable (Hutchison *et al.*, 2021). Therefore, should impacts from EMF occur, they would be limited to within a few metres to few tens of metres of the cable and not represent a significant barrier to migration for this species.

**Freshwater pearl mussel**

293. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraphs 291 and 292, EMFs from subsea electrical cabling in the operation and maintenance phase are unlikely to result in barriers to migration for Atlantic salmon. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Conclusion**

294. Adverse effects on the qualifying Annex II diadromous fish features of the River Oykel SAC which undermine the conservation objectives of the SAC will not occur a result of subsea electrical cabling during the operation and maintenance phase. Potential effects from this impact on the relevant conservation objectives (as presented in paragraphs 146 to 148) are discussed in turn below in Table 5.32.

**Table 5.32: Conclusions Against the Conservation Objectives of the River Oykel SAC from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2020d) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site | Any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There is therefore negligible risk of disruption to migration for Atlantic salmon, and this impact will not prevent the populations of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored. |
| | 2b. Restore the distribution of Atlantic salmon throughout the site | |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site | As a freshwater resident species, there is no direct pathway for impact associated with EMFs from subsea electrical cabling associated with the Array and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, EMFs will not lead to barriers to migration. Therefore, it can also be concluded that this impact will not indirectly prevent the populations of this species from being a viable component of this site or the distributions of this species from being restored. |
| | 2b. Restore the distribution of freshwater pearl mussel throughout the site | |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between EMFs from subsea electrical cabling and the habitats that support freshwater pearl mussel within this SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

295. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Oykel SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phase of the Array alone.

## 5.4. ASSESSMENT OF ADVERSE EFFECTS OF THE ARRAY IN-COMBINATION WITH OTHER PLANS AND PROJECTS

### 5.4.1. PLANS AND PROJECTS SCREENED INTO THE IN-COMBINATION ASSESSMENT FOR ANNEX II DIADROMOUS FISH

296. A buffer of 50 km was used to identify plans and projects with the potential for in-combination effects associated with EMF. To account for the wider ranging impacts associated with underwater noise, a precautionary buffer of 100 km was used to identify plans and projects with the potential for in-combination effects associated with underwater noise generated during piling and UXO clearance (Figure 5.4).

297. Given the limited available data about Tier 3 projects, projects were screened in initially based on temporal and/or spatial overlap as a precautionary approach. However, there was limited/no information on the construction/operation dates, nor foundation types proposed. Therefore, for potential impacts arising from piling and UXO clearance, which require these more detailed parameters, there was insufficient information to carry out a full quantitative assessment. A qualitative assessment has therefore been undertaken, based on the available information.

298. The plans and projects that have been identified as having the potential for in-combination effects are presented in Figure 5.4 and Table 5.33.

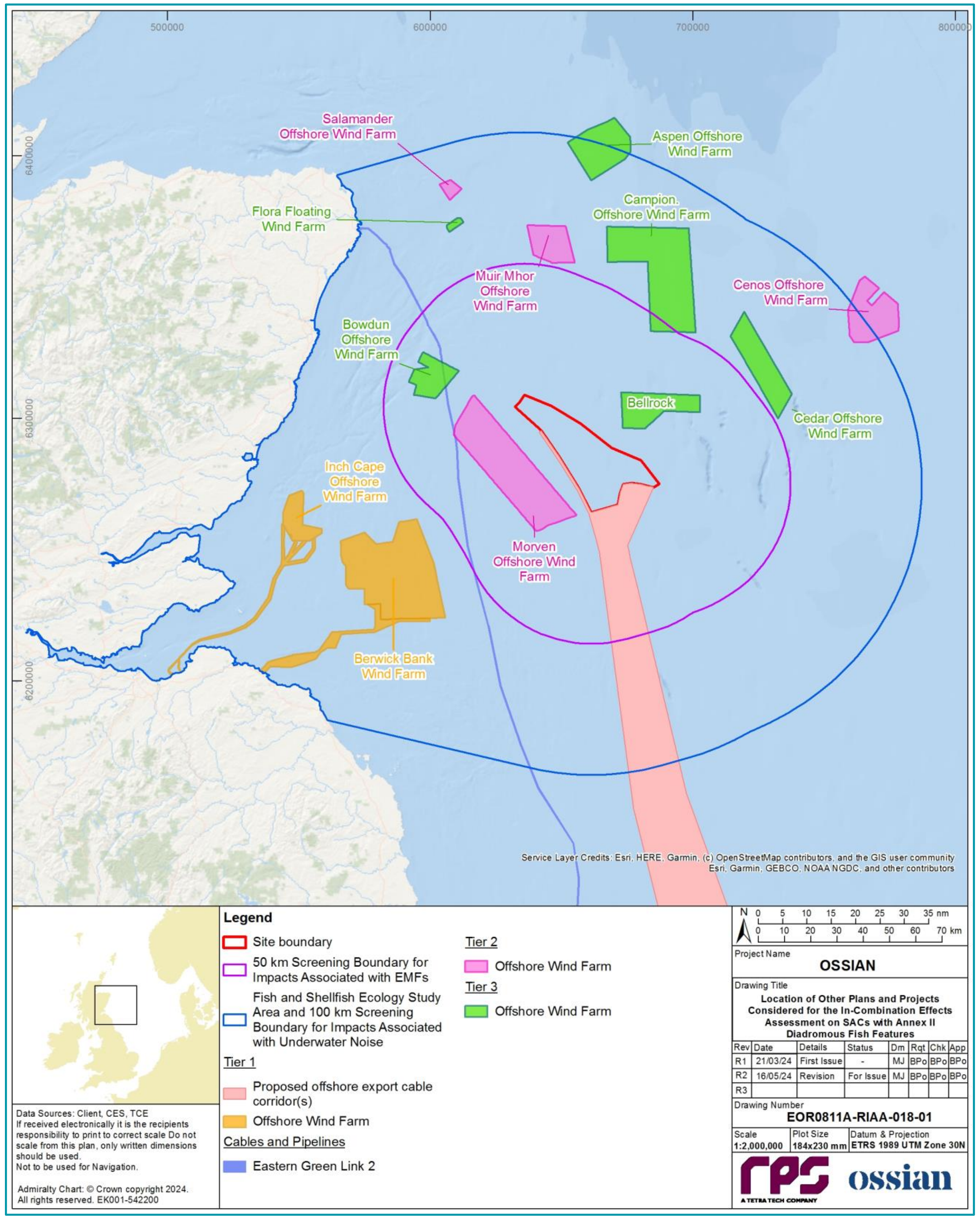


**Figure 5.4:** Location of Other Plans and Projects Considered for the In-Combination Effects Assessment on SACs with Annex II Diadromous Fish Features

**Table 5.33: List of Other Plans and Projects with Potential for In-Combination Effects on Annex II Diadromous Fish Features**

| Project/PI | Status [i.e. Application, Consented, Under Construction, Operational] | Distance from Array Area (km) | Description of Project/Plan | Dates of Construction (If Applicable) | Dates of Operation (If Applicable) | Overlap with the Array |
|---|---|---|---|---|---|---|
| **Tier 1** | | | | | | |
| Proposed offshore export cable corridor(s) | Planned | 0.00 | The Proposed offshore export cable corridor(s) for the Array | 2030 to 2038 | 2038 to 2072 | Spatial overlap with the screening buffer and temporal overlap between the construction and operation and maintenance phases of the Array. |
| **Offshore Wind Projects and Associated Cables** | | | | | | |
| Berwick Bank Offshore Wind Farm | Planning | 56.84 | Berwick Bank Offshore Wind Farm is proposed for up to 307 wind turbines with a capacity of up to 4.1 GW | 2025 to 2032 | 2033 to 2057 | Outside spatial overlap for the in-combination assessment on EMFs (i.e. 50 km buffer), but within screening buffer for underwater noise (i.e. 100 km). |
| **Cables and Pipelines** | | | | | | |
| Eastern Green Link 2 | Marine Licence Application | 24.37 | Transmission cable between Scotland and England | 2026 to 2029 | 2030 to 2050 | Spatial overlap with the screening buffers for both EMF and underwater noise, and no temporal overlap with the construction phase. Operation and maintenance phase of Eastern Green Link 2 overlaps temporally with that of the Array. |
| **Tier 2** | | | | | | |
| **Offshore Wind Projects and Associated Cables** | | | | | | |
| Morven Offshore Wind Farm) | Scoping | 5.50 | Up to 191 wind turbines at a capacity of 2,300 MW | 2031 to 2038 | 2038 onwards | Spatial overlap with the screening buffers for both EMF and underwater noise. Construction and operation and maintenance phases of Morven overlap temporally with those of the Array. Full overlap between the Morven Construction and Operational phases and those of the Ossian Array have been in the absence of available dates for construction and operation of this project. This is considered to be a precautionary approach as it assumes greatest spatial impact. |
| Muir Mhor Offshore Wind Farm | Scoping | 51.38 | Project expected to start construction in 2026 with commercial operation starting in 2030[1] | 2027 to 2029 | 2030 to 2055 | Outside spatial overlap for the in-combination assessment on EMFs (i.e. 50 km buffer), but within screening buffer for underwater noise (i.e. 100 km). Operation and maintenance phase of Muir Mhor Offshore Wind Farm overlaps temporally with that of the Array. Given that the impact of underwater noise generated during piling and UXO clearance is only relevant to the construction phase, this project is not included further within the in-combination assessment due to the lack of temporal overlap in construction. |
| Cenos Offshore Wind Farm | Scoping | 91.70 | Cenos Offshore Wind Farm is proposed for up to 1,400 MW. | Unknown | Unknown | Outside spatial overlap for the in-combination assessment on EMFs (i.e. 50 km buffer), but within screening buffer for underwater noise (i.e. 100 km). The construction phase of Cenos Offshore Wind Farm might overlap with the construction and operation and maintenance phases of the Array. |

[1] Dates based on latest publicly available information

| Project/Pl | Status [i.e. Application, Consented, Under Construction, Operational] | Distance from Array Area (km) | Description of Project/Plan | Dates of Construction (If Applicable) | Dates of Operation (If Applicable) | Overlap with the Array |
|---|---|---|---|---|---|---|
| Salamander Offshore Wind Farm | Scoping | 79.49 | Salamander Offshore Wind Farm is proposed for up to 100 MW. | Unknown | Unknown | Outside spatial overlap for the in-combination assessment on EMFs (i.e. 50 km buffer), but within screening buffer for underwater noise (i.e. 100 km). The construction phase of Salamander Offshore Wind Farm might overlap with the construction and operation and maintenance phases of the Array. |
| **Tier 3** | | | | | | |
| **Offshore Wind Projects and Associated Cables** | | | | | | |
| Morven Offshore Export Cable Corridor(s) | Pre-planning | 5.50 | Proposed offshore export cable corridor(s) for Morven Offshore Wind Farm | Unknown | Unknown | Spatial overlap with the screening buffers for both EMF and underwater noise. The construction phase of Morven Offshore Wind Farm might overlap with the construction and operation and maintenance phases of the Array. |
| Bellrock Offshore Wind Farm | Pre-Planning | 8.67 | Bellrock Offshore Wind Farm is proposed for a capacity of 1200MW. | Unknown | Unknown | Spatial overlap with the screening buffers for both EMF and underwater noise. The construction phase of Bellrock Offshore Wind Farm might overlap with the construction and operation and maintenance phases of the Array. |
| Bowdun Offshore Wind Farm | Pre-Planning | 25.36 | Up to 60 wind turbines at a capacity of 1,000 MW | Unknown | Unknown | Spatial overlap with the screening buffers for both EMF and underwater noise. The construction phase of Bowdun Offshore Wind Farm might overlap with the construction and operation and maintenance phases of the Array. |
| Campion Offshore Wind Farm | Pre-Planning | 44.15 | Up to 100 wind turbines at a capacity of 2,000 MW | Unknown | Unknown | Spatial overlap with the screening buffers for both EMF and underwater noise. The construction phase of Campion Offshore Wind Farm might overlap with the construction and operation and maintenance phases of the Array. |
| Cedar Offshore Wind Farm | Pre-Planning | 51.65 | Cedar is proposed for up to 1,008 MW. | Unknown | Unknown | Spatial overlap with screening buffer for underwater noise impacts only (100 km). The construction phase of Cedar Offshore Wind Farm might overlap with the construction and operation and maintenance phases of the Array. |
| Flora Floating Wind Farm | Pre-Planning | 68.41 | Flora Floating Wind Farm is proposed for up to 50 MW. | Unknown | Unknown | Spatial overlap with screening buffer for underwater noise impacts only (100 km). The construction phase of Flora Floating Wind Farm might overlap with the construction and operation and maintenance phases of the Array. |
| Aspen Offshore Wind Farm | Pre-Planning | 85.61 | Aspen Offshore Wind Farm is proposed for up to 1008 MW. | Unknown | Unknown | Spatial overlap with screening buffer for underwater noise impacts only (100 km). The construction phase of Aspen Offshore Wind Farm might overlap with the construction and operation and maintenance phases of the Array. |
| **Cables and Pipelines** | | | | | | |
| Eastern Green Link 3 | Planned | Unknown | Transmission cable between Scotland and England (between Peterhead and Lincolnshire) | Unknown | Unknown | The construction phase of Eastern Green Link 3 might overlap with the construction and operation and maintenance phases of the Array. |
| Eastern Green Link 4 | Planned | Unknown | Transmission cable between Scotland and England | Unknown | Unknown | The construction phase of Eastern Green Link 4 might overlap with the construction and operation and maintenance phases of the Array. |

### 5.4.2. UNDERWATER NOISE GENERATED DURING PILING AND UXO CLEARANCE

299. The LSE[2] assessment during the HRA Stage One process identified that LSE[2] could not be ruled out for underwater noise generated during piling and UXO clearance in the construction phase of the Array in-combination with other plans and projects. This relates to the following sites and relevant Annex II diadromous fish features:

- River Dee SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.
- River South Esk SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.
- Tweed Estuary SAC;
  - sea lamprey.
- River Tweed SAC;
  - Atlantic salmon; and
  - sea lamprey.
- River Tay SAC;
  - Atlantic salmon; and
  - sea lamprey.
- River Spey SAC;
  - Atlantic salmon;
  - freshwater pearl mussel; and
  - sea lamprey.
- Berriedale and Langwell Waters SAC; and
  - Atlantic salmon; and
  - sea lamprey.
- River Teith SAC;
  - Atlantic salmon; and
  - sea lamprey.
- River Oykel SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.

300. The MDS considered for this in-combination assessment is shown in Table 5.34. The designed in measures are presented in Table 5.4 for the assessment of the Array alone.

**Table 5.34: MDS Considered for the Assessment of Potential Impacts to Annex II Diadromous Fish due to Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Project Phase | Tier | MDS |
|---|---|---|
| Construction | 1 | The MDS is as described above for the Array alone (Table 5.3) has been assessed in-combination with the following plans and projects:<br><br>**Construction Phase**<br>• Proposed offshore export cable corridor(s); and<br>• Berwick Bank Offshore Wind Farm. |
| | 2 | The MDS is as described above for the Array alone (Table 5.3) and has been assessed in-combination with the following plans and projects:<br><br>**Construction Phase**<br>• Morven Offshore Wind Farm;<br>• Cenos Offshore Wind Farm;<br>• Salamander Offshore Wind Farm; and<br>• Tier 1 projects. |
| | 3 | The MDS is as described above for the Array alone (Table 5.3) and has been assessed in-combination with the following plans and projects:<br><br>**Construction Phase**<br>• Morven Offshore Export Cable Corridor(s);<br>• Bellrock Offshore Wind Farm;<br>• Bowdun Offshore Wind Farm;<br>• Campion Offshore Wind Farm;<br>• Cedar Offshore Wind Farm;<br>• Flora Floating Wind Farm;<br>• Aspen Offshore Wind Farm; and<br>• Tier 1 and Tier 2 projects. |

#### In-combination assessment

301. There is the potential for in-combination impacts from underwater noise generated during piling and UXO clearance in the construction phases of the Array and other plans and projects. For the purposes of this assessment, this impact has been assessed using the tiered approach outlined in section 4.6. The plans and projects screened into the in-combination assessment for this potential impact and their respective tiers are outlined in Table 5.34.

Tier 1

302. There were two Tier 1 projects identified with potential for in-combination effects associated with this impact:

- Proposed offshore export cable corridor(s); and
- Berwick Bank Offshore Wind Farm (Table 5.33 and Table 5.34).

303. The MDS for the Array's construction phase is given in Table 5.3, which considers the reasonable worst case scenario from underwater noise on Annex II diadromous fish based on the greatest hammer energy. This scenario is represented by the installation of up to 265 semi-submersible floating foundations, with up to six anchors per foundation and one 4.5 m diameter pile per anchor (1,590 piles) for wind turbines,

and up to three large and 12 small jacket foundations (total 216 piles) for OSPs, with all piles installed via impact piling.

304. Currently, there is no EIA Report available for the Proposed offshore export cable corridor(s), though construction is likely to be of medium duration, with noise being intermittent. Although there is no information on construction activities associated with the Proposed offshore export cable corridor(s), it is not expected that piling will be included in the project description (as this is a cable project). As such, noise impacts which have the potential to affect Atlantic salmon (and freshwater pearl mussel by association) and sea lamprey are expected to be limited to UXO clearance operations during site preparation. While there is no site-specific information on these impacts, it is expected they would be similar to those assessed for the project alone (section 5.3.1).

305. The EIA Report for Berwick Bank Offshore Wind Farm accounts for clearance of up to 14 UXOs (a maximum of 300 kg) within its inter-array area or offshore export cable route, and single donor charge of up to 80 g NEQ for each clearance event (SSE Renewables, 2022b). Up to 500 g NEQ may be used for a clearance shot to neutralise residual explosive material, with up to two destinations within 24 hours and clearance occurring during daylight only (SSE Renewables, 2022b).

306. During the construction phase for the Berwick Bank Offshore Wind Farm, up to 179 piled jacket foundations with up to four legs per foundation (1,432 piles) have been assessed for wind turbines. The maximum hammer energy is up to 4,000 kJ with a realistic maximum hammer energy of 3,000 kJ. Two concurrent piling events will occur with a minimum of 900 m and maximum of 49.3 km distance between these two events. Up to ten hours of absolute maximum piling per pile may occur with a wind turbine piling duration of 14,320 hours and a realistic maximum of 12,888 hours (SSE Renewables, 2022b).

307. During the construction phase for the Berwick Bank Offshore Wind Farm, up to eight jacket foundations with up to six legs per foundation (64 piles) have been assessed for large OSPs/offshore converter substation platforms, with a maximum hammer energy of 4,000 kJ. Piling may occur for up to eight hours, with a total piling duration of 1,792 hours (realistic maximum) or 2,048 hours (absolute maximum). The total piling phase is over 52 months over a construction period of 96 months (SSE Renewables, 2022b).

308. The Berwick Bank Offshore Wind Farm underwater noise assessment considered effects (including mortality, injury and behavioural effects) on a similar range of fish and shellfish receptors as the Array. In line with the assessment for the Array alone, the Berwick Bank assessment predicted that injury effects would be limited in extent and behavioural effects would occur across a wider area of up to tens of kilometres (SSE Renewables, 2022b). The effects would be temporary, reversible and would not result in significant effects on fish and shellfish receptors, and specifically would not lead to disruption of migration (e.g. barrier effects) of diadromous species, including Atlantic salmon and sea lamprey (SSE Renewables, 2022b). Within the RIAA for Berwick Bank Offshore Wind Farm, the following SACs were assessed:

- River Dee SAC;
- River South Esk SAC;
- Tweed Estuary SAC;
- River Tweed SAC;
- River Tay SAC; and
- River Teith SAC (SSE Renewables, 2022e).

309. All of these SACs were also included in this Part of the RIAA, however the River Spey SAC, Berriedale and Langwell Waters SAC, and the River Oykel SAC were not assessed in the Berwick Bank RIAA (SSE Renewables, 2022e). The potential impact of ‘injury and/or disturbance from underwater noise’ was not concluded to have adverse effects on the integrity of any of the six SACs assessed both from Berwick Bank alone, and in-combination with other plans and projects (SSE Renewables, 2022e).

310. The construction of the Array, and of Berwick Bank Offshore Wind Farm, will coincide for only two years (2031 and 2032). Furthermore, due to the large distance between the projects (56.84 km), there is limited potential for noise contours to interact. Given that UXO clearance is typically undertaken at the beginning of the construction phase, there is likely to be no temporal overlap in UXO clearance associated with the Array and Berwick Bank Offshore Wind Farm (where the construction phase is currently anticipated as 2025 to 2032 (Table 5.33)).

Tier 2

311. In addition to the Tier 1 projects, there were three Tier 2 projects identified with potential for in-combination effects associated with this impact:

- Morven Offshore Wind Farm;
- Cenos Offshore Wind Farm; and
- Salamander Offshore Wind Farm (Table 5.33 and Table 5.34).

312. The MDS for the construction of the Array is given in Table 5.3, and summarised in paragraph 303, and not repeated here. Currently, there is no EIA Report available for the Tier 2 projects, though piling activities during the construction phases are expected to be similar in nature as that of the Array. Although information on hammer energies and piling durations are not available for the Tier 2 projects, the impact is likely to be of medium duration, with noise being intermittent during the construction phase. As detailed in Table 5.33, the construction phase of the Morven Offshore Wind Farm is anticipated to overlap temporally with that of the Array, and full overlap has been assumed in the absence of detailed information and to represent the realistic worst case scenario, due to its proximity to the Array (5.5 km). At this stage, the construction phases of the other Tier 2 projects are currently unknown.

Tier 3

313. In addition to the Tier 1 and Tier 2 projects, there were seven Tier 3 projects identified with potential for in-combination effects associated with this impact:

- Morven Offshore Export Cable Corridor(s);
- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm;
- Cedar Offshore Wind Farm;
- Flora Floating Wind Farm; and
- Aspen Offshore Wind Farm (Table 5.33 and Table 5.34).

314. As these are Tier 3 projects, there are no Scoping Reports in the public domain. Therefore, there is limited information available on the potential impact that these Tier 3 projects will have on Annex II diadromous fish, though piling activities during the construction phase are expected to be similar in nature as that of the Array. Although information on hammer energies and piling durations are not available for the Tier 3 projects, the impact is likely to be of medium duration, with noise being intermittent during the construction phase.

315. The maximum duration of the offshore construction phase for the Array is up to eight years (2031 to 2038). There is currently no information available on the various Tier 3 projects; therefore, a precautionary assumption has been made that these may have overlapping piling phases with the Array (Table 5.33 and Table 5.34). In reality, there may be limited temporal overlap between the construction activities of the Array and that of the Tier 3 projects, and thus, reduced potential for in-combination effects associated with this impact.

316. Furthermore, given the maximum injury ranges for the Annex II diadromous fish species associated with piling and UXO clearance from the Array alone (between hundreds of metres to low kilometres), there is low likelihood of any spatial overlap of ranges between the Array and the Tier 3 projects. For example, the closest Tier 3 projects are the Morven Offshore Export Cable Corridor (5.5 km away) and Bellrock Offshore Wind Farm (8.67 km away), with the rest multiple tens of kilometres away. Further, the potential for PTS is reduced through the application of designed-in measures (Table 5.4), either by allowing some species/individuals to flee the area before noise levels reach a level at which injury may occur, and/or by

limiting the total amount of noise energy entering the environment. Therefore there is limited potential for an in-combination impact associated with the Tier 3 projects, and each project will likely implement their own mitigation to limit injury and disturbance, thus further reducing the potential for in-combination effects associated with piling and UXO clearance.

### Construction phase

River Dee SAC

**Atlantic salmon**

317. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects in reality, may have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to Atlantic salmon. Therefore, the assessment is considered to be precautionary.

**Freshwater pearl mussel**

318. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraph 317, injury, disturbance, and barriers to migration of Atlantic salmon are unlikely to occur from the Array in-combination with other plans and projects. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Conclusion**

319. Adverse effects on the qualifying Annex II diadromous fish features of the River Dee SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling and UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraphs 69 to 71) are discussed in turn below in Table 5.35.

**Table 5.35: Conclusions Against the Conservation Objectives of the River Dee SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020c) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site | As detailed by the results of the underwater noise modelling for the Array alone, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within its EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). The Berwick Bank RIAA concluded no adverse effect on the integrity of this SAC both alone, and in-combination with other plans and projects (SSE Renewables, 2022e).<br><br>Atlantic salmon are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures of the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This impact will not prevent the populations of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this impact will not prevent the populations of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored. |
| | 2b. Restore the distribution of Atlantic salmon throughout the site | |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support Atlantic salmon within the site and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site | As a freshwater resident species, there is no direct pathway for impact associated with underwater noise and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that underwater noise will not indirectly prevent the populations of this species from being a viable component of this site or the distributions of this species from being restored. |
| | 2b. Restore the distribution of freshwater pearl mussel throughout the site | |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between underwater noise generated during the construction phase and the habitats that support freshwater pearl mussel and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

320. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Dee SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phases of the Array in-combination with other plans and projects.

River South Esk SAC

**Atlantic salmon**

321. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects may in reality, have limited overlap, and therefore the potential for in-combination effects are reduced Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to Atlantic salmon. Therefore, the assessment is considered to be precautionary.

**Freshwater pearl mussel**

322. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraph 321, injury, disturbance, and barriers to migration of Atlantic salmon are unlikely to occur from the Array in-combination with other plans and projects. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Conclusion**

323. Adverse effects on the qualifying Annex II diadromous fish features of the River South Esk SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling and UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraphs 78 to 80) are discussed in turn below in Table 5.36.

**Table 5.36: Conclusions Against the Conservation Objectives of the River South Esk SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020e) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site | As detailed by the results of the underwater noise modelling for the Array alone, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). The Berwick Bank RIAA concluded no adverse effect on the integrity of this SAC both alone, and in-combination with other plans and projects (SSE Renewables, 2022e).<br><br>Atlantic salmon are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this impact will not prevent the populations of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored. |
| | 2b. Restore the distribution of Atlantic salmon throughout the site | |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support Atlantic salmon within the site and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site | As a freshwater resident species, there is no direct pathway for impact associated with underwater noise and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that underwater noise will not indirectly prevent the populations of this species from being a viable component of this site or the distributions of this species from being restored. |
| | 2b. Restore the distribution of freshwater pearl mussel throughout the site | |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between underwater noise generated during the construction phase and the habitats that support freshwater pearl mussel and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

324. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River South Esk SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phases of the Array in-combination with other plans and projects.

Tweed Estuary SAC

**Sea lamprey**

325. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the sea lamprey feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium-term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects in reality, may have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to sea lamprey. Therefore, the assessment is considered to be precautionary.

**Conclusion**

326. Adverse effects on the qualifying Annex II diadromous fish features of the Tweed Estuary SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling and UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraphs 90 to 92) are discussed in turn below in Table 5.37.

**Table 5.37: Conclusions Against the Conservation Objectives of the Tweed Estuary SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (Natural England, 2018) | Conclusion |
|---|---|---|
| Sea lamprey | The extent and distribution of qualifying natural habitats and habitats of the qualifying species [are maintained or restored]<br>The structure and function of the habitats of the qualifying species [are maintained or restored]<br>The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely [are maintained or restored] | There is no pathway for impact between underwater noise generated during the construction phase and the habitats and supporting processes that support the sea lamprey feature. Therefore, this impact will not prevent the extent, distribution, structure, function, and supporting processes of the sea lamprey habitats within the site from being maintained or restored. |
| | The populations of each of the qualifying species [are maintained or restored]<br>The distribution qualifying species within the site [are maintained or restored] | As detailed by the results of the underwater noise modelling for the Array alone, sea lamprey within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). The Berwick Bank RIAA concluded no adverse effect on the integrity of this SAC both alone, and in-combination with other plans and projects (SSE Renewables, 2022e).<br><br>Sea lamprey are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures, including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations or the distributions of this species from being maintained or restored.<br><br>Sea lamprey may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of sea lamprey due to behavioural disturbance. Therefore, this impact will not prevent the populations or the distributions of this species from being maintained or restored. |

327. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Tweed Estuary SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phases of the Array in-combination with other plans and projects.

River Tweed SAC

**Atlantic salmon**

328. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects, in reality, may have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to Atlantic salmon. Therefore, the assessment is considered to be precautionary.

**Sea lamprey**

329. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the sea lamprey feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects, in reality, may have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to sea lamprey. Therefore, the assessment is considered to be precautionary.

**Conclusion**

330. Adverse effects on the qualifying Annex II diadromous fish features of the River Tweed SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling and UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraphs 99 to 101) are discussed in turn below in Table 5.38.

**Table 5.38: Conclusions Against the Conservation Objectives of the River Tweed SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (Natural England, 2022, NatureScot, 2020h) | Conclusion |
|---|---|---|
| **NatureScot Conservation Objectives** | | |
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Maintain the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling for the Array alone, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). The Berwick Bank RIAA concluded no adverse effect on the integrity of this SAC both alone, and in-combination with other plans and projects (SSE Renewables, 2022e).<br><br>Atlantic salmon are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures, including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations of this species from being maintained as a viable component of this site or the distributions or genetic diversity of this species from being maintained.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this potential impact will not prevent the populations of this species from being maintained as a viable component of this site or the distribution or genetic diversity of this species from being maintained. |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support Atlantic salmon within the site and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site<br>2b. Maintain the distribution of the sea lamprey throughout the site | As detailed by the results of the underwater noise modelling for the Array alone, sea lamprey within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). The Berwick Bank RIAA concluded no adverse effect on the integrity of this SAC both alone, and in-combination with other plans and projects (SSE Renewables, 2022e).<br><br>Sea lamprey are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures, including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations of this species from being a viable component of this site or the distributions of this species from being maintained or restored.<br><br>Sea lamprey may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this potential impact will not prevent the populations of this species from being a viable component of this site or the distribution of this species from being maintained or restored. |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support sea lamprey within the site and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained or restored. |
| **Natural England Conservation Objectives** | | |
| Atlantic salmon and sea lamprey | The extent and distribution of qualifying natural habitats and habitats of qualifying species [is maintained or restored]<br>The structure and function of the habitats of qualifying species [is maintained or restored]<br>The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely [are maintained or restored] | There is no pathway for impact between underwater noise generated during the construction phase and the habitats and supporting processes that support the Atlantic salmon and sea lamprey qualifying features. Therefore, this potential impact will not prevent the extent, distribution, structure, function, and supporting processes of their habitats within the site from being maintained or restored. |
| | The populations of qualifying species [are maintained or restored'<br>The distribution of qualifying species within the site [are maintained or restored] | As detailed above for the NatureScot conservation objectives, this impact will not prevent the populations and distribution of the Atlantic salmon and sea lamprey qualifying features from being maintained or restored. |

331. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Tweed SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phases of the Array in-combination with other plans and projects.

River Tay SAC

**Atlantic salmon**

332. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects, in reality, may have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to Atlantic salmon. Therefore, the assessment is considered to be precautionary.

**Sea lamprey**

333. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the sea lamprey feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects, in reality, may have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to sea lamprey. Therefore, the assessment is considered to be precautionary.

**Conclusion**

334. Adverse effects on the qualifying Annex II diadromous fish features of the River Tay SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling and UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraphs 113 to 115) are discussed in turn below in Table 5.39.

**Table 5.39: Conclusions Against the Conservation Objectives of the River Tay SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020g) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br><br>2b. Maintain the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling for the Array alone, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). The Berwick Bank RIAA concluded no adverse effect on the integrity of this SAC both alone, and in-combination with other plans and projects (SSE Renewables, 2022e).<br><br>Atlantic salmon are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures, including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations of this species from being maintained as a viable component of this site or the distributions or genetic diversity of this species from being maintained.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this potential impact will not prevent the populations of this species from being maintained as a viable component of this site or the distributions or genetic diversity of this species from being maintained. |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support Atlantic salmon within the site and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site<br><br>2b. Maintain the distribution of the sea lamprey throughout the site | As detailed by the results of the underwater noise modelling for the Array alone, sea lamprey within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). The Berwick Bank RIAA concluded no adverse effect on the integrity of this SAC both alone, and in-combination with other plans and projects (SSE Renewables, 2022e).<br><br>Sea lamprey are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures, including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations of this species from being a viable component of this site or the distributions of this species from being maintained.<br><br>Sea lamprey may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this potential impact will not prevent the populations of this species from being a viable component of this site or the distributions of this species from being maintained. |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support sea lamprey within the site and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained. |

335. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Tay SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phases of the Array in-combination with other plans and projects

River Spey SAC

**Atlantic salmon**

336. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects may, in reality, have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to Atlantic salmon. Therefore, the assessment is considered to be precautionary.

**Freshwater pearl mussel**

337. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraph 336, injury, disturbance, and barriers to migration of Atlantic salmon are unlikely to occur from the Array in-combination with other plans and projects. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Sea lamprey**

338. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the sea lamprey feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects may, in reality, have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to sea lamprey. Therefore, the assessment is considered to be precautionary.

**Conclusion**

339. Adverse effects on the qualifying Annex II diadromous fish features of the River Spey SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling and UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraphs 123 to 126) are discussed in turn below in Table 5.40.

**Table 5.40: Conclusions Against the Conservation Objectives of the River Spey SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020f) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling for the Array alone, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). However, this SAC was not screened into the RIAA for Berwick Bank (SSE Renewables, 2022e).<br><br>Atlantic salmon are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures, including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations of this species from being as a viable component of this site or the distributions or genetic diversity of this species from being restored.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this potential impact will not prevent the populations of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support Atlantic salmon within the site and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with underwater noise and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that underwater noise will not indirectly prevent the populations of this species from being a viable component of this site or the distributions of this species from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between underwater noise generated during the construction phase and the habitats that support freshwater pearl mussel and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this potential impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site<br>2b. Maintain the distribution of the sea lamprey throughout the site | As detailed by the results of the underwater noise modelling for the Array alone, sea lamprey within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). However, this SAC was not screened into the RIAA for Berwick Bank (SSE Renewables, 2022e).<br><br>Sea lamprey are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures, including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations of this species from being a viable component of this site or the distributions of this species from being maintained.<br><br>Sea lamprey may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this potential impact will not prevent the populations of this species from being a viable component of this site or the distributions of this species from being maintained. |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support sea lamprey within the site and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained. |

340. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Spey SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phases of the Array in-combination with other plans and projects.

Berriedale and Langwell Waters SAC

**Atlantic salmon**

341. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium-term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects, in reality, may have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to Atlantic salmon. Therefore, the assessment is considered to be precautionary.

**Conclusion**

342. Adverse effects on the qualifying Annex II diadromous fish features of the Berriedale and Langwell Waters SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling and UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraph 133) are discussed in turn below in Table 5.41.

**Table 5.41: Conclusions Against the Conservation Objectives of the Berriedale and Langwell Waters SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020b) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Maintain the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling for the Array alone, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). However, this SAC was not screened into the RIAA for Berwick Bank (SSE Renewables, 2022e).<br><br>Atlantic salmon are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures, including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations of this species from being maintained as a viable component of this site or the distributions or genetic diversity of this species from being maintained.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this potential impact will not prevent the populations of this species from being maintained as a viable component of this site or the distributions or genetic diversity of this species from being maintained. |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support Atlantic salmon within the site and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained. |

343. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berriedale and Langwell Waters SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phases of the Array in-combination with other plans and projects.

River Teith SAC

**Atlantic salmon**

344. As presented for the assessment of the Array alone (section 5.3.1), this impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium-term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects, in reality, may have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to Atlantic salmon. Therefore, the assessment is considered to be precautionary.

**Sea lamprey**

345. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the sea lamprey feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium-term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects, in reality, may have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to sea lamprey. Therefore, the assessment is considered to be precautionary.

**Conclusion**

346. Adverse effects on the qualifying Annex II diadromous fish features of the River Teith SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling and UXO clearance in the construction phase. Potential effects from these activities on the relevant conservation objectives (as presented in paragraph 140) are discussed in turn below in Table 5.42. As stated in paragraph 140, a CAP has not yet been published for the River Teith SAC, and therefore, only the overarching conservation objectives for all qualifying species features are presented in Table 5.42 for Atlantic salmon and sea lamprey combined. The assessment has therefore been undertaken with regard to the available conservation objectives for the site (NatureScot, 2015).

**Table 5.42: Conclusions Against the Conservation Objectives of the River Teith SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (JNCC, 2015) | Conclusion |
|---|---|---|
| Atlantic salmon and sea lamprey | The population of the species, including range of genetic types for Atlantic salmon, as a viable component of the site is maintained in the long term<br>The distribution of the species within the site is maintained in the long term | As detailed by the results of the underwater noise modelling for the Array alone, Atlantic salmon and sea lamprey within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). The Berwick Bank RIAA concluded no adverse effect on the integrity of this SAC both alone, and in-combination with other plans and projects (SSE Renewables, 2022e).<br><br>Atlantic salmon and sea lamprey are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures, including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations of these species from being viable components of this site or the distributions or genetic diversity of these species from being maintained in the long term.<br><br>Atlantic salmon and sea lamprey may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this impact will not prevent the populations of these species from being viable components of this site or the distributions or genetic diversity of these species from being maintained in the long term. |
| | The distribution and extent of habitats supporting the species is maintained in the long term<br>The structure, function and supporting processes of habitats supporting the species is maintained in the long term | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support these species within the site and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained. |
| | There is no significant disturbance of the species | As stated in the rows above for the populations and distributions of Atlantic salmon and sea lamprey, there is negligible risk to these species in terms of behavioural disturbance caused by underwater noise. Therefore, this potential impact will not cause significant disturbance of Atlantic salmon and sea lamprey. |

347. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Teith SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phases of the Array in-combination with other plans and projects.

River Oykel SAC

**Atlantic salmon**

348. As presented for the assessment of the Array alone (section 5.3.1), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 302 *et seq.,* this conclusion is also applicable to the in-combination assessment. Any in-combination effects are predicted to be of short to medium term duration (such as short term UXO clearance, and more medium-term piling schedules) and intermittent in nature. Further, the construction phases of the Array and those of the Tier 1, 2, and 3 projects, in reality, may have limited overlap, and therefore the potential for in-combination effects are reduced. Finally, it is likely that the Tier 1, 2, and 3 projects will also include similar designed in mitigation measures as those proposed for the Array (Table 5.4), which will further reduce the total amount of acoustic energy emitted into the marine environment and the likelihood of injury, disturbance, and barrier effects to Atlantic salmon. Therefore, the assessment is considered to be precautionary.

**Freshwater pearl mussel**

349. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraph 348, injury, disturbance, and barriers to migration of Atlantic salmon are unlikely to occur from the Array in-combination with other plans and projects. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

**Conclusion**

350. Adverse effects on the qualifying Annex II diadromous fish features of the River Oykel SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling and UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraphs 146 to 148) are discussed in turn below in Table 5.43

**Table 5.43: Conclusions Against the Conservation Objectives of the River Oykel SAC from Underwater Noise Generated during Piling and UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020d) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | As detailed by the results of the underwater noise modelling for the Array alone, Atlantic salmon within close proximity to piling and UXO clearance may experience injury or mortality. The only other project with publicly available modelling was Berwick Bank (Tier 1). Within the Berwick Bank EIA, similar potential impacts to that of the Array were reported, with injurious effects limited in extent and behavioural effects potentially occurring across tens of kilometres (SSE Renewables, 2022b). However, this SAC was not screened into the RIAA for Berwick Bank (SSE Renewables, 2022e).<br><br>Atlantic salmon are highly mobile and may only use the fish and shellfish ecology study area to pass through during migration. As such, and with additional consideration of the designed in measures, including the use of soft start piling procedures and low order UXO detonation, significant mortality or injury to this species is not predicted. These designed in measures are based on SNCB advice and considered standard practice across the offshore wind industry. Therefore, it is considered likely that they would  adopted as standard across the Tier 1, 2, and 3 projects. This potential impact will not prevent the populations of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored.<br><br>Atlantic salmon may also experience behavioural effects in response to piling associated with the Array in-combination with other plans and projects, but the modelling at the Array and Berwick Bank Offshore Wind Farm indicates these effects would not result in barriers to migration to and from this SAC. Further, underwater noise from piling will be short term and intermittent during the construction phase of the different projects. As above for injury and mortality, there is therefore negligible risk of disruption to migration of Atlantic salmon due to behavioural disturbance. Therefore, this potential impact will not prevent the populations of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between underwater noise generated during the construction phase and the habitats that support Atlantic salmon within the site and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with underwater noise and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, underwater noise in the construction phase will not lead to significant mortality or injury to Atlantic salmon and is unlikely to result in barriers to migration. Therefore, it can also be concluded that underwater noise will not indirectly prevent the populations of this species from being a viable component of this site or the distributions of this species from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between underwater noise generated during the construction phase and the habitats that support freshwater pearl mussel and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

351. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Oykel SAC as a result of underwater noise generated during piling and UXO clearance with respect to the construction phases of the Array in-combination with other plans and projects.

### 5.4.3. EFFECTS DUE TO EMFS FROM SUBSEA ELECTRICAL CABLING

352. The LSE[2] assessment during the HRA Stage One process identified that LSE[2] could not be ruled out for effects due to EMFs from subsea electrical cables in the operation and maintenance phase of the Array in-combination with other plans and projects. This relates to the following sites and relevant Annex II diadromous fish features:

- River Dee SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.
- River South Esk SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.
- Tweed Estuary SAC;
  - sea lamprey.
- River Tweed SAC;
  - Atlantic salmon; and
  - sea lamprey.
- River Tay SAC;
  - Atlantic salmon; and
  - sea lamprey.
- River Spey SAC;
  - Atlantic salmon;
  - freshwater pearl mussel; and
  - sea lamprey.
- Berriedale and Langwell Waters SAC; and
  - Atlantic salmon; and
  - sea lamprey.
- River Teith SAC;
  - Atlantic salmon; and
  - sea lamprey.
- River Oykel SAC;
  - Atlantic salmon; and
  - freshwater pearl mussel.

353. The MDS considered for this in-combination assessment is shown in Table 5.44.

**Table 5.44: MDS Considered for the Assessment of Potential Impacts to Annex II Diadromous Fish due to EMFs from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Project Phase | Tier | MDS |
|---|---|---|
| Operation and maintenance | 1 | The MDS is as described above for the Array alone (Table 5.23) and has been assessed in-combination with the following plans and projects:<br><br>**Construction Phase**<br>• Proposed offshore export cable corridor(s); and<br>• Eastern Green Link 2. |
| | 2 | The MDS is as described above for the Array alone (Table 5.23) and has been assessed in-combination with the following plans and projects:<br><br>**Construction Phase**<br>• Morven Offshore Wind Farm; and<br>• Tier 1 projects. |
| | 3 | The MDS is as described above for the Array alone (Table 5.3) and has been assessed in-combination with the following plans and projects:<br><br>**Construction Phase**<br>• Morven Offshore Export Cable Corridor(s);<br>• Bellrock Offshore Wind Farm;<br>• Bowdun Offshore Wind Farm;<br>• Campion Offshore Wind Farm;<br>• Eastern Green Link 3;<br>• Eastern Green Link 4; and<br>• Tier 1 and Tier 2 projects. |

In-combination assessment

354. There is potential for EMFs to be produced by the subsea electrical cables associated with the Array and the other plans and projects during their operation and maintenance phases. For the purposes of this assessment, this potential impact has been assessed using the tiered approach outlined in section 4.6. The plans and projects screened into the in-combination assessment for this potential impact and their respective tiers are outlined in Table 5.44.

<u>Tier 1</u>

355. There were two Tier 1 projects identified with potential for in-combination effects associated with this impact:

- Proposed offshore export cable corridor(s); and
- Eastern Green Link 2 (Table 5.33 and Table 5.44).

356. At the time of writing, there was no EIA Report available for the Proposed offshore export cable corridor(s). However, given that these two Tier 1 projects are both HVDC subsea power cables (and in contrast to the Array, they will not include dynamic cabling) it is expected these will be entirely buried, or protected where burial is not possible. For example, the Environmental Appraisal Report for the Eastern Green Link 2 presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022).

357. The MDS for the Array accounts for up to 1,261 km of 66 kV inter-array cables, with up to 116 km as 'dynamic cables' in the water column, and the rest buried at a depth of at least 0.4 m (Table 5.23). There will also be up to 236 km of interconnector cables buried to a minimum depth of 0.4 m and maximum depth of 3 m. It has been estimated in the MDS that up to 20% of these buried cables will require cable protection, with up to 24 cable crossings also requiring protection. The Eastern Green Link 2 project has two 436 km HVDC cables, totalling 872 km of subsea cabling which may emit EMFs (National Grid Electricity Transmission *et al.*, 2022), which extend outside the fish and shellfish ecology study area.

358. In contrast with the Array, neither of the Tier 1 projects will include dynamic cables. As Atlantic salmon and sea lamprey are likely to use the pelagic zone of the water column, opposed to the seabed, they are less likely to interact with EMFs emitted from subsea cables buried or on the seabed. This further reduces the potential for in-combination effects associated with the Tier 1 projects.

359. As detailed in section 5.3.2 for the assessment of the Array alone, EMF levels in the vicinity of subsea cables are influenced by a variety of design and installation factors, including distance between cables, cable sheathing, number of conductors, and internal cable configuration. Further, the intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al.*, 2021). This attenuation is the same for buried, unburied, and dynamic cables (Hutchison *et al.*, 2021). Therefore, the in-combination impact with the Tier 1 projects is likely to be highly localised to within metres to tens of metres from cables.

Tier 2

360. In addition to the Tier 1 projects, there was one Tier 2 project identified with potential for in-combination effects associated with this impact: the operation and maintenance phase of the Morven Offshore Wind Farm (Table 5.33 and Table 5.44). The MDS for the Array is summarised in paragraph 357, and has not been repeated here,. As only a Scoping Report is available for the Morven Offshore Wind Farm, cable lengths, dimensions, and voltages are not currently available. However, given the scale of the project, it is likely that they will be of a similar extent to those of the Array, albeit with less dynamic cabling given that the Morven Offshore Wind Farm is not a floating project.

361. As detailed in section 5.3.2 for the assessment of the Array alone and within the Tier 1 assessment, EMF levels in the vicinity of subsea cables are influenced by a variety of design and installation factors, including distance between cables, cable sheathing, number of conductors, and internal cable configuration. Further, the intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al.*, 2021). This attenuation is the same for buried, unburied, and dynamic cables (Hutchison *et al.*, 2021). Therefore, the cumulative magnitude of impact with the Tier 2 projects is likely to be highly localised to within metres to tens of metres from cables.

Tier 3

362. In addition to the Tier 1 and Tier 2 projects, there were six Tier 3 projects identified with potential for in-combination effects associated with this impact:

- Morven Offshore Export Cable Corridor(s);
- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm;
- Eastern Green Link 3; and
- Eastern Green Link 4 (Table 5.33 and Table 5.44).

363. The MDS for the Array is summarised in paragraph 357, and has not been repeated here. As Tier 3 projects, there is no project specific information regarding cable lengths, dimension, and voltages currently available in the public domain. However, given the scale of the projects, it is likely that EMF related impacts associated with the Bellrock, Bowdun, and Campion Offshore Wind Farms will be of a similar in nature and extent to those of the Array and Morven Offshore Wind Farm. The Morven Offshore Export Cable Corridor(s) is likely to be similar in nature and extent to that of the Array (the Proposed offshore export cable corridor(s) in Tier 1). Finally, the Eastern Green Link 3 and 4 are likely to be similar to the Eastern Green Link 2 (Tier 1; paragraph 356).

364. As detailed in section 5.3.2 for the assessment of the Array alone and within the Tier 1 assessment, EMF levels in the vicinity of subsea cables are influenced by a variety of design and installation factors, including distance between cables, cable sheathing, number of conductors, and internal cable configuration. Further, the intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al.*, 2021). This attenuation is the same for buried, unburied, and dynamic cables (Hutchison *et al.*, 2021). Therefore, the in-combination magnitude of impact with the Tier 3 projects is likely to be highly localised to within metres to tens of metres from cables.

### Operation and Maintenance Phase

River Dee SAC

Atlantic salmon

365. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where practicable, which will further reduce the distance between cables and migrating diadromous fish.

Freshwater pearl mussel

366. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraph 365, EMFs from subsea electrical cabling in the operation and maintenance phases of the Tier 1, 2, and 3 projects are unlikely to result in barriers to migration for Atlantic salmon. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

Conclusion

367. Adverse effects on the qualifying Annex II diadromous fish features of the River Dee SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination EMF from subsea electrical cables during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented paragraphs 69 to 71) are discussed in turn below in Table 5.45.

**Table 5.45: Conclusions Against the Conservation Objectives of the River Dee SAC from EMFs from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020c) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for Atlantic salmon, and this impact will not prevent the population of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with EMFs from subsea electrical cabling associated with the Array and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, EMFs will not lead to barriers to migration. Therefore, it can also be concluded that this potential impact will not indirectly prevent the populations of this species from being a viable component of this site or the distributions of this species from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between EMFs from subsea electrical cabling and the habitats that support freshwater pearl mussel and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this potential impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

368. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Dee SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phases of the Array in-combination with other plans and projects.

River South Esk SAC

Atlantic salmon

369. As presented for the assessment of the Array alone (section 5.3.2), this impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Freshwater pearl mussel

370. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraph 369, EMFs from subsea electrical cabling in the operation and maintenance phases of the Tier 1, 2, and 3 projects are unlikely to result in barriers to migration for Atlantic salmon. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

Conclusion

371. Adverse effects on the qualifying Annex II diadromous fish features of the River South Esk SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination EMF from subsea electrical cables during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented paragraphs 78 to 80) are discussed in turn below in Table 5.46.

**Table 5.46: Conclusions Against the Conservation Objectives of the River South Esk SAC from EMFs from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020e) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for Atlantic salmon, and this impact will not prevent the population of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored. |
| | 2b. Restore the distribution of Atlantic salmon throughout the site | |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site | As a freshwater resident species, there is no direct pathway for impact associated with EMFs from subsea electrical cabling associated with the Array and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, EMFs will not lead to barriers to migration. Therefore, it can also be concluded that this impact will not indirectly prevent the population of this species from being a viable component of this site or the distributions of this species from being restored. |
| | 2b. Restore the distribution of freshwater pearl mussel throughout the site | |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between EMFs from subsea electrical cabling and the habitats that support freshwater pearl mussel and availability of food. Therefore, this impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

372. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River South Esk SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phases of the Array in-combination with other plans and projects.

Tweed Estuary SAC

Sea lamprey

373. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the sea lamprey feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Conclusion

374. Adverse effects on the qualifying Annex II diadromous fish features of the Tweed Estuary SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination EMF from subsea electrical cables during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented paragraph 90) are discussed in turn below in Table 5.47.

**Table 5.47: Conclusions Against the Conservation Objectives of the Tweed Estuary SAC from EMFs from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (Natural England, 2018) | Conclusion |
|---|---|---|
| Sea lamprey | The extent and distribution of qualifying natural habitats and habitats of the qualifying species [are maintained or restored] | There is no pathway for impact between EMFs from subsea electrical cabling and the habitats and supporting processes that support the sea lamprey feature. Therefore, this potential impact will not prevent the extent, distribution, structure, function, and supporting processes of the sea lamprey habitats within the site from being maintained or restored. |
| | The structure and function of the habitats of the qualifying species [are maintained or restored] | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely [are maintained or restored] | |
| | The populations of each of the qualifying species [are maintained or restored] | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for sea lamprey, and this potential impact will not prevent the population or the distribution of this species from being maintained or restored. |
| | The distribution qualifying species within the site [are maintained or restored] | |

375. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Tweed Estuary SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phases of the Array in-combination with other plans and projects. River Tweed SAC

River Tweed SAC

Atlantic salmon

376. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Sea lamprey

377. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the sea lamprey feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Conclusion

378. Adverse effects on the qualifying Annex II diadromous fish features of the River Tweed SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination EMF from subsea electrical cables during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented paragraphs 97 to 101) are discussed in turn below in Table 5.48.

**Table 5.48: Conclusions Against the Conservation Objectives of the River Tweed SAC from EMFs from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (Natural England, 2022, NatureScot, 2020h) | Conclusion |
|---|---|---|
| **NatureScot Conservation Objectives** | | |
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for Atlantic salmon, and this potential impact will not prevent the population of this species from being maintained as a viable component of this site or the distributions or genetic diversity of this species from being maintained. |
| | 2b. Maintain the distribution of Atlantic salmon throughout the site | |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained or restored. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for sea lamprey, and this impact will not prevent the population of this species from being maintained as a viable component of this site or the distributions of this species from being maintained or restored. |
| | 2b. Maintain the distribution of the sea lamprey throughout the site | |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support sea lamprey within the SAC and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained or restored. |
| **Natural England Conservation Objectives** | | |
| Atlantic salmon and sea lamprey | The extent and distribution of qualifying natural habitats and habitats of qualifying species [is maintained or restored] | There is no pathway for impact between EMFs from subsea electrical cabling and the habitats and supporting processes that support the Atlantic salmon and sea lamprey qualifying features. Therefore, this potential impact will not prevent the extent, distribution, structure, function, and supporting processes of their habitats within the site from being maintained or restored. |
| | The structure and function of the habitats of qualifying species [is maintained or restored] | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely [are maintained or restored] | |
| | The populations of qualifying species [are maintained or restored' | As detailed above for the NatureScot conservation objectives, this impact will not prevent the populations and distribution of the Atlantic salmon and sea lamprey qualifying features from being maintained or restored. |
| | The distribution of qualifying species within the site [are maintained or restored] | |

379. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Tweed SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phases of the Array in-combination with other plans and projects. River Tweed SAC

River Tay SAC

Atlantic salmon

380. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Sea lamprey

381. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the sea lamprey feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Conclusion

382. Adverse effects on the qualifying Annex II diadromous fish features of the River Tay SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination EMF from subsea electrical cables during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented paragraphs 113 to 115) are discussed in turn below in Table 5.49.

**Table 5.49: Conclusions Against the Conservation Objectives of the River Tay SAC from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020g) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Maintain the distribution of Atlantic salmon throughout the site | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for Atlantic salmon, and this potential impact will not prevent the population of this species from being maintained as a viable component of this site or the distributions or genetic diversity of this species from being maintained. |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site<br>2b. Maintain the distribution of the sea lamprey throughout the site | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for sea lamprey, and this potential impact will not prevent the population of this species from being maintained as a viable component of this site or the distributions of this species from being maintained. |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support sea lamprey within the SAC and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained. |

383. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Tay SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phases of the Array in-combination with other plans and projects.

River Spey SAC

Atlantic salmon

384. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further

reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Freshwater pearl mussel

385. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraph 384, EMFs from subsea electrical cabling in the operation and maintenance phases of the Tier 1, 2, and 3 projects are unlikely to result in barriers to migration for Atlantic salmon. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

Sea lamprey

386. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the sea lamprey feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Conclusion

387. Adverse effects on the qualifying Annex II diadromous fish features of the River Spey SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination EMF from subsea electrical cables during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraphs 123 to 126) are discussed in turn below in Table 5.50.

**Table 5.50: Conclusions Against the Conservation Objectives of the River Spey SAC from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020f) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for Atlantic salmon, and this potential impact will not prevent the population of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored, |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with EMFs from subsea electrical cabling associated with the Array and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, EMFs will not lead to barriers to migration. Therefore, it can also be concluded that this potential impact will not indirectly prevent the population of this species from being a viable component of this site or the distributions of this species from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between EMFs from subsea electrical cabling and the habitats that support freshwater pearl mussel and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this potential impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |
| Sea lamprey | 2a. Maintain the population of the sea lamprey as viable components of the site<br>2b. Maintain the distribution of the sea lamprey throughout the site | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for sea lamprey, and this potential impact will not prevent the population of this species from being a viable component of this site or the distributions of this species from being maintained. |
| | 2c. Maintain the habitats supporting the sea lamprey within the site, and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support sea lamprey within the SAC and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained. |

388. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Spey SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phases of the Array in-combination with other plans and projects.

Berriedale and Langwell Waters SAC

Atlantic salmon

389. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Conclusion

390. Adverse effects on the qualifying Annex II diadromous fish features of the Berriedale and Langwell Waters SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination EMF from subsea electrical cables during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraph 133) are discussed in turn below in Table 5.51.

**Table 5.51: Conclusions Against the Conservation Objectives of the Berriedale and Langwell Waters SAC from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020b) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Maintain the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Maintain the distribution of Atlantic salmon throughout the site | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for Atlantic salmon, and this potential impact will not prevent the population of this species from being maintained as a viable component of this site or the distributions or genetic diversity of this species from being maintained. |
| | 2c. Maintain the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being maintained. |

391. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berriedale and Langwell Waters SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phases of the Array in-combination with other plans and projects.

River Teith SAC

Atlantic salmon

392. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Sea lamprey

393. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the sea lamprey feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Conclusion

394. Adverse effects on the qualifying Annex II diadromous fish features of the River Teith SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination EMFs from subsea electrical cabling in the operation and maintenance phase. Potential effects from this impact on the relevant conservation objectives (as presented in paragraph 140) are discussed in turn below in Table 5.52. As stated in paragraph 140, a CAP has not yet been published for the River Teith SAC, and therefore, only the overarching conservation objectives for all qualifying species features are presented in Table 5.52 for Atlantic salmon and sea lamprey combined. The assessment has therefore been undertaken with regard to the available conservation objectives for the site (NatureScot, 2015).

**Table 5.52: Conclusions Against the Conservation Objectives of the River Teith SAC from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (JNCC, 2015) | Conclusion |
|---|---|---|
| Atlantic salmon and sea lamprey | The population of the species, including range of genetic types for Atlantic salmon, as a viable component of the site is maintained in the long term<br>The distribution of the species within the site is maintained in the long term | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for Atlantic salmon and sea lamprey, and this potential impact will not prevent the populations of these species from being viable components of this site or the distributions or genetic diversity of these species from being maintained in the long term. |
| | The distribution and extent of habitats supporting the species is maintained in the long term<br>The structure, function and supporting processes of habitats supporting the species is maintained in the long term | There is no pathway for impact between EMFs from subsea electrical cabling and the distribution, extent, structure, function, and supporting processes of the habitats that support Atlantic salmon and sea lamprey. Therefore, this potential impact will not prevent these aspects of Atlantic salmon and sea lamprey habitats from being maintained in the long term. |
| | There is no significant disturbance of the species | As any potential behavioural effects from EMFs will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. Therefore, this potential impact will not cause significant disturbance of Atlantic salmon and sea lamprey. |

395. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the River Teith SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phases of the Array in-combination with other plans and projects.

River Oykel SAC

Atlantic salmon

396. As presented for the assessment of the Array alone (section 5.3.2), this potential impact was not predicted to cause an adverse effect on integrity to the Atlantic salmon feature of this site. Based on the Tier 1, 2, and 3 assessments presented in paragraph 355 *et seq.,* this conclusion is also applicable to the in-combination assessment. Whilst any in-combination effects will be continuous and persist over the life cycles of each plan and project, they are likely to be highly localised in extent (i.e. within metres to a maximum of tens of metres from cables). Therefore, any in-combination impacts associated with EMFs will be confined to the immediate vicinity of cables associated with the Tiers 1, 2, and 3 projects. Further, for projects which with no dynamic cables, only those on the seabed, the in-combination impact is further reduced given the pelagic nature of diadromous fish offshore. Finally, it is likely that all the Tier 1, 2, and 3 projects will include cable burial and protection, where possible, which will further reduce the distance between cables and migrating diadromous fish.

Freshwater pearl mussel

397. Adult freshwater pearl mussel are confined to freshwater environments, and there is therefore no pathway for direct effects associated with this impact. However, there is potential for indirect impacts on the larval stage of freshwater pearl mussel if Atlantic salmon (their host species) are impacted. As detailed in paragraph 396, EMFs from subsea electrical cabling in the operation and maintenance phases of the Tier 1, 2, and 3 projects are unlikely to result in barriers to migration for Atlantic salmon. Therefore, it can also be concluded that there will be no indirect impact to freshwater pearl mussel.

Conclusion

398. Adverse effects on the qualifying Annex II diadromous fish features of the River Oykel SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination EMF from subsea electrical cables during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in paragraphs 146 to 148) are discussed in turn below in Table 5.53

**Table 5.53: Conclusions Against the Conservation Objectives of the River Oykel SAC from Subsea Electrical Cabling in the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2020d) | Conclusion |
|---|---|---|
| Atlantic salmon | 2a. Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site<br>2b. Restore the distribution of Atlantic salmon throughout the site | For the Array and the Tier 1, 2, and 3 projects, any effects of EMF from subsea electrical cabling will be highly localised (i.e. metres to a maximum of tens of metres around cables) within the fish and shellfish ecology study area. There was limited publicly available information on any of the Tier 1, 2, and 3 projects, except for the Eastern Green Link 2 (Tier 1). The Environmental Appraisal Report for this project presented calculations that a burial depth of 1 m reduced EMFs to background levels by 20 m distance from the cable (National Grid Electricity Transmission *et al.*, 2022). There is therefore negligible risk of disruption to migration for Atlantic salmon, and this potential impact will not prevent the population of this species from being a viable component of this site or the distributions or genetic diversity of this species from being restored. |
| | 2c. Restore the habitats supporting Atlantic salmon within the site and availability of food | There is no pathway for impact between EMFs from subsea electrical cables and the habitats that support Atlantic salmon within the SAC and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being restored. |
| Freshwater pearl mussel | 2a. Restore the population of freshwater pearl mussel as a viable component of the site<br>2b. Restore the distribution of freshwater pearl mussel throughout the site | As a freshwater resident species, there is no direct pathway for impact associated with EMFs from subsea electrical cabling associated with the Array and the population and distribution of freshwater pearl mussel within the site. As presented in the rows above for Atlantic salmon, EMFs will not lead to barriers to migration. Therefore, it can also be concluded that this potential impact will not indirectly prevent the population of this species from being a viable component of this site or the distributions of this species from being restored. |
| | 2c. Restore the habitats supporting freshwater pearl mussel within the site and availability of food | As above for Atlantic salmon, there is no pathway for impact between EMFs from subsea electrical cabling and the habitats that support freshwater pearl mussel and availability of food. Therefore, this potential impact will not prevent the habitats within the site and availability of food from being restored. |
| | 2d. Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats | As presented in the rows above for Atlantic salmon, this potential impact will not prevent the distribution and viability of Atlantic salmon and its supporting habitats from being restored. |

399. It can be concluded beyond reasonable scientific doubt that there is no risk of an adverse effect on the integrity of the River Oykel SAC as a result of EMFs from subsea electrical cabling with respect to the operation and maintenance phases of the Array in-combination with other plans and projects.

# 6. ASSESSMENT OF POTENTIAL ADVERSE EFFECTS ON INTEGRITY: ANNEX II MARINE MAMMALS

## 6.1. INTRODUCTION

400. This section provides background information and explanation for the approach taken to assess the potential impacts of the Array on European sites designated for Annex II Marine Mammals.

401. As stated in section 3.1, the potential for LSE[2] was identified for the Annex II marine mammal features of three SACs, which are listed in Table 6.1 and Figure 6.1. These SACs were agreed to be screened in for further assessment with NatureScot, Natural England, and MD-LOT during the Ossian Array Scoping Opinion and LSE[2] Screening process (see Table 2.1 for all relevant consultation).

**Table 6.1: European Sites Designated for Annex II Marine Mammal Features for which an Appropriate Assessment is Presented**

| Site | Feature | Period of Impact |
|---|---|---|
| Berwickshire and North Northumberland Coast SAC | Grey seal | Construction and operation and maintenance phases |
| Southern North Sea SAC | Harbour porpoise | |
| Moray Firth SAC | Bottlenose dolphin | |

402. LSE[2]s on the SACs presented in Table 5.1 were identified for the construction and operation and maintenance phases of the Array, which are outlined below in Table 6.2. These impacts were agreed upon with NatureScot, Natural England, and MD-LOT during the Ossian Array Scoping Opinion and LSE[2] Screening process (see Table 2.1 for all relevant consultation).

**Table 6.2: Potential Impacts to Annex II Marine Mammals of the European Sites Identified for Appropriate Assessment**

| Project Phase | Potential Impact |
|---|---|
| Construction | Underwater noise generated during piling |
| | Underwater noise generated during UXO clearance |
| | Injury and disturbance due to site-investigation surveys (including geophysical surveys) |
| | Changes in prey availability |
| Operation and Maintenance | Entanglement |
| | Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines |
| | Injury and disturbance due to site-investigation surveys (including geophysical surveys) |

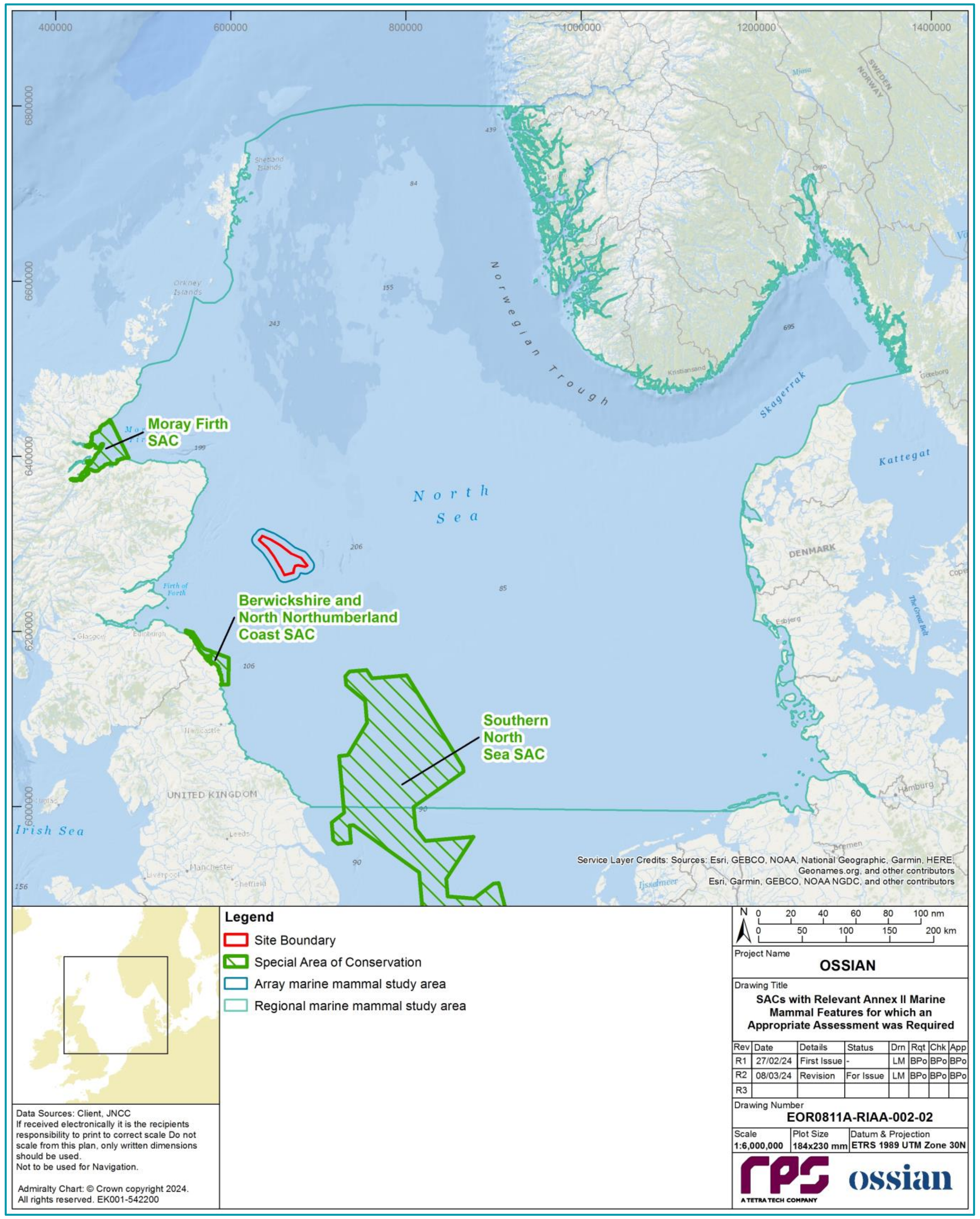


**Figure 6.1: Location of European Sites Designated for Annex II Marine Mammals for which an Appropriate Assessment is Presented**

## 6.2. BASELINE

403. Baseline information on the Annex II marine mammal features of the three European sites identified for Appropriate Assessment within the HRA process has been gathered through a comprehensive desktop study of existing datasets and materials and site-specific Digital Aerial Surveys (DAS). Full detail is provided in volume 2, chapter 10 and volume 3, appendix 10.2 of the Array EIA Report.

404. Within the Array EIA Report, two marine mammal study areas were defined for the purposes of the baseline characterisation (Ossian OWFL, 2024):

- the Array marine mammal study area: an area encompassing the site boundary plus an 8 km buffer. This area also corresponds with the site-specific survey area, in which 24 months of DAS were conducted; and
- the regional marine mammal study area: an area encompassing the wider northern North Sea to account for the highly mobile nature of marine mammals. The boundaries of the northern North Sea are closely aligned with those of Marine Protected Areas (Wildlife Trusts, 2023) (Figure 6.1).

### 6.2.1. BERWICKSHIRE AND NORTH NORTHUMBERLAND COAST SAC

#### Site description

405. At its closest point, the Berwickshire and North Northumberland Coast SAC is located 113.95 km south-west from the site boundary. The Berwickshire and North Northumberland Coast SAC is one of the most varied coastlines in the UK, stretching from Alnmouth to north of St Abbs head (Figure 6.1). It contains a complex mix of marine habitats, associated species and communities which is unusually diverse for the North Sea, in both a UK and European context (Natural England, 2020). It covers an area of 65,226.12 ha and is designated for Annex I habitats and Annex II grey seal (JNCC, 2024b).

406. The SAC is an extensive and diverse stretch of coastline which provides important habitats for grey seal, supporting approximately 3% of the British annual pup production (JNCC, 2024b, Natural England, 2020). Grey seals use areas within the SAC, such as Staple Island within the Farne Islands, for breeding, hauling out and moulting (Natural England, 2020). A large number of grey seal also haul out around Holy Island sands, Lindisfarne, however, no breeding has been recorded here to date (Natural England, 2020). The SAC represents the most south eastern grey seal breeding colonies in the UK, and it is the most south-easterly SAC designated for this species (JNCC, 2024b).

#### Feature accounts

Grey seal

407. Grey seal is the larger of the two pinniped species which occur around the UK and Ireland, with the other being harbour seal. Males weigh up to 300 kg and females weigh up to 200 kg (SCOS, 2023). The average lifespan for grey seal ranges between 20 to 30 years, however, females tend to live longer than males. Females mature at between three and five years old and males around six years, although it is reported they they are unlikely to be socially mature until eight years old (Hall *et al.*, 2009).

408. Grey seals breed, rest, moult and engage in social activity when they gather in colonies on land (known as haul outs). Haul out events occur also at sea on exposed sandbanks, but their frequency is low, and their duration is on average shorter than those events on land (Russell *et al.*, 2012).

409. Female grey seal tends to return to the same breeding site at which they were born in order to give birth. Preferred breeding locations in the UK include remote, uninhabited islands or coasts and in small numbers in caves (SCOS, 2022). These sites allow females with young pups to move inland away from busy beaches and storm surges. Seals may also breed on exposed, cliff-backed beaches but these locations limit the opportunity to avoid storm surges and it may result in higher levels of pup mortality (SCOS, 2022). In the UK, grey seals breed in the autumn, but there is a clockwise cline in the mean birth date around the UK (SCOS, 2022). The majority of pups in south-west Britain are born between August and October; in north and west Scotland pupping occurs mainly between September and late November; in east Scotland between August and December and in eastern England pupping occurs mainly between early November to mid-December. Grey seal give birth to a single, white-coated pup which is weaned over a period of 17 to 23 days (SCOS, 2022). Pups shed their white natal coat (lanugo) and develop their first adult coat, with moult occurring at the time of weaning after which pups remain on the breeding colony for up to two to three weeks before going to sea. Following this, the female comes into oestrus and mating occurs, after which adult females return to sea to forage and build up fat reserves.

410. Along the Scottish coast, grey seals exhibit an offshore foraging behaviour (Damseaux *et al.*, 2021). Wyles *et al.* (2022) studied the influence of geomorphological features of the seabed on at-sea behaviour of grey seal. The study found that features such as slopes, foot slopes and hollows attract grey seal individuals as these may host prey aggregations, and/or lead to increased prey capture success. Grey seal have a selective diet. A study on the diet of grey seals in Scottish waters found that 50% of prey items were plaice *Pleuronectes platessa* and sole and 46% of prey items were sandeels (Damseaux *et al.*, 2021). Hammond *et al.* (2005) also highlighted that grey seal diet comprises primarily sandeels, gadoids and flatfish, in that order of importance, but varying seasonally and from region to region. Gosch (2017) also reported that there are significant regional and temporal differences in the diet of grey seal. Those in shallow waters show a preference for demersal and groundfish species such as cephalopods and flatfish, whilst seals foraging in deeper waters, over sandy substrates, will target pelagic and benthopelagic species such as blue whiting *Micromesistius poutassou* and sandeels (Gosch, 2017).

411. Grey seals tend to forage in the open sea, returning to land regularly to haul out. Foraging trips can be wide-ranging, however, tracking studies have shown that most foraging is likely to occur within 100 km of a haul out site (SCOS, 2022). During breeding season grey seal tend to forage within 20 km from the breeding site (*pers. comm.* with NatureScot).

412. The east coast of Scotland and northern England where this SAC is located provide important breeding and haul-out habitats for grey seal. The UK total grey seal population size at the start of the 2022 breeding season was estimated to be 162,000 grey seals of which 129,100 (approximately 80%) were in Scotland (Stevens, 2023). The most recent August grey seal counts took place in 2021 in both East Scotland and Northeast England SMU and resulted in a scaled August population estimates of 10,783 and 25,913 grey seals, respectively (SCOS, 2023), using the 25.15% scalar derived from Russell *et al.* (2021). Based on density heatmaps by Carter *et al.* (2022), mean grey seal at-sea usage within the site boundary is low, as the hotspots are located closer to the shore and in the vicinity of the Berwickshire and North Northumberland Coast SAC, Firth of Forth, Tay and Eden Estuary and north of Aberdeen. Grey seal was recorded in low numbers during monthly site-specific DAS with 18 animals recorded over nine months. The annual mean design-based density (corrected for availability bias) was estimated as 0.021 animals per $km^2$ with density during non-breeding season (January to August) being higher at 0.034 animals per $km^2$. Tagging data illustrated a high-level of connectivity between the Array marine mammal study area and the Berwickshire and North Northumberland Coast SAC, with approximately 9% of tagged individuals being tracked within both. Given the uncertainty associated with identification of seals to species level based on DAS data, density estimates reported by Carter *et al.* (2022) are considered the most appropriate to use and a density of 0.180 animals per $km^2$ has been taken forward for Appropriate Assessment (see section 5.3.2 in volume 3, appendix 10.2 of the Array EIA Report for more details regarding the most appropriate density value to be taken forward to the assessment).

#### Conservation objectives

413. The conservation objectives for Berwickshire and North Northumberland Coast SAC have been developed jointly by NatureScot and Natural England and apply to the site and the individual species (e.g. grey seal) for which the site has been classified. These high-level objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the FCS of its qualifying features, by maintaining or restoring:

- the extent and distribution of qualifying natural habitat and habitats of the qualifying species;
- the structure and function (including typical species) of qualifying natural habitats;
- the structure and function of the habitats of the qualifying species;
- the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;
- the populations of each of the qualifying species; and
- the distribution of qualifying species within the site (Natural England, 2020).

414. The second conservation objective: 'the structure and function (including typical species) of qualifying natural habitats' is only relevant to the Annex I habitat features of the Berwickshire and North Northumberland Coast SAC and is therefore not included further in this assessment on Annex II marine mammals.

415. Supplementary advice on conservation objectives (published on 9 May 2023) (Natural England, 2023a) provides the site-specific attributes and targets specific to the grey seal feature of the SAC. Conservation targets for grey seal are summarised here:

- maintain the population size within the site;
- maintain the reproductive and recruitment capability of the species;
- maintain the presence and spatial distribution of the species and their ability to undertake key life cycle stages and behaviours;
- maintain connectivity of the habitat within sites and the wider environment to ensure recruitment, and/or to allow movement of migratory species;
- restrict the introduction and spread of INNS and pathogens, and their impacts;
- maintain the extent and spatial distribution of the following supporting habitats: haul out sites;
- maintain the cover and abundance of preferred food items required by the species;
- maintain the natural physico-chemical properties of the water;
- maintain all hydrodynamic and physical conditions such that natural water flow and sediment movement is not significantly altered or constrained;
- reduce aqueous contaminants to levels equating to High Status according to Annex VIII and Good Status according to Annex X of the WFD, avoiding deterioration from existing levels;
- maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features; and
- maintain natural levels of turbidity in areas where this species is, or could be, present (Natural England, 2023a).

#### Condition assessment

416. There was no condition assessment currently available on the Natural England Designated Sites Portal (Natural England, 2020), however, the condition of grey seal was assessed by NatureScot in 2014 as:

- grey seal: favourable – maintained (NatureScot, 2024).

### 6.2.2. SOUTHERN NORTH SEA SAC

#### Site description

417. At its closest point, the Southern North Sea SAC is located 129.86 km south-east from the site boundary. The Southern North Sea SAC covers an area of 36,951 km$^2$, and is designated solely for harbour porpoise (JNCC, 2023d, JNCC and Natural England, 2019). The site lies along the east coast of England, predominantly in the offshore waters of the central and southern North Sea, from north of Dogger Bank to the Straits of Dover in the south (Figure 6.1).

418. The Southern North Sea SAC is an area of importance for harbour porpoise, supporting an estimated 17.5% of the UK North Sea MU population. Approximately two-thirds of the site, the northern part, is recognised as important for the species during the summer, whilst the southern part supports persistently higher densities during the winter (JNCC, 2023d). The majority of this site lies offshore but does extend from the coastal areas of Norfolk and Suffolk out to the 12 nm limit. Therefore, both Natural England and JNCC are responsible for providing statutory advice (JNCC and Natural England, 2019).

#### Feature accounts

Harbour porpoise

419. The harbour porpoise is a small odontocete (i.e. toothed whale) inhabiting coastal temperate and boreal waters of the northern hemisphere. It reaches a maximum length of 1.9 m (Bjørge *et al.*, 2009), with females growing to an average length of 1.6 m whilst males reach 1.45 m in length (Lockyer, 1995). Although the recorded longevity is 24 years, most individuals do not live past 12 years of age (Lockyer, 2013).

420. The geographic range of harbour porpoise coincides with cool, high latitude waters. Because harbour porpoise have a greater body surface area to volume ratio than other, larger cetacean species, this causes them to potentially lose energy through radiation and conduction to the surrounding water (Kastelein *et al.*, 2018a, Kastelein *et al.*, 2019a, Lambert, 2020). To maintain their body temperature and other energy needs, they need to feed frequently and consume enough prey per unit body weight (Rojano-Doñate *et al.*, 2018). For this reason, porpoise may be susceptible to changes in the abundance of prey species or disturbance from foraging areas. Given that harbour porpoise are predated on by other odontocetes (killer whale) and pinnipeds (grey seal), they often flee when encountering predators (Kastelein *et al.*, 2019b). As such, it can be anticipated that harbour porpoise have adaptive mechanisms over certain time scales and the time when harbour porpoise are not feeding may extend to up to 9 to 12 hours (Kastelein *et al.*, 2019b). Recent studies in Iceland suggest that despite ecosystem changes in the study region, harbour porpoise show no long term changes in trophic ecology, indicating that this species may be able to adapt to spatial changes in prey distribution or shift to other prey at similar trophic levels (Samarra *et al.*, 2022).

421. Across various datasets, harbour porpoise counts were consistently higher during the summer months. During aerial surveys of the Firth of Forth, harbour porpoise were recorded nearly three times as often in summer (2.01 sightings per 100 km) compared to winter (0.70 sightings per 100 km) (Grellier *et al.*, 2011). The same pattern of higher encounter rates during summer months was also recorded during boat-based surveys for Seagreen 1 Offshore Wind Farm, which lies in the inner Firth of Forth (Sparling, 2012). Boat-based surveys in summer 2017 recorded the highest counts of harbour porpoise between May and July within the Seagreen 1 Offshore Wind Farm (Seagreen Wind Energy Limited, 2018). Similarly, analysis of aerial survey data for the Berwick Bank Offshore Wind Farm (also within the Firth of Forth) presented highest encounter rates during spring each year (April and May) and lowest during winter and autumn (from November 2019 to March 2020 and from October 2020 to February 2021) (SSE Renewables, 2022d). The monthly encounter rate for harbour porpoise from the site-specific DAS data varied across months with the encounter rate for summer (specifically July 2021, April 2022, June 2022, and July 2022) estimated to be considerably higher compared to other seasons of the year.

422. Harbour porpoise accounted for the highest number of sightings identified to species level (based on raw count data) during site-specific DAS and was recorded in all but three survey months. It was the most commonly identified cetacean during historic aerial surveys in the wider Firth of Forth and Tay region (Grellier *et al.*, 2011, Sparling, 2012, SSE Renewables, 2022d). IAMMWG (2022) presented estimated abundance for the North Sea MU as 346,601 individuals. The most recent Small Cetaceans in European Atlantic Waters and the North Sea (SCANS) survey data (SCANS-IV) estimated the density in block NS-D, where the site boundary is located, as 0.5985 harbour porpoise per km$^2$ and presented an abundance of 38,577 individuals (Gilles *et al.*, 2023). Site-specific modelled estimates from the DAS provided a mean encounter rate of 0.041 animals per km with a monthly peak of 0.154 animals per km in July 2021. The annual mean model-based density (corrected for availability bias) was estimated as 0.355 animals per km$^2$ with summer density being higher at 0.648 animals per km. Design-based absolute density estimates using

DAS sightings data are considered the most appropriate to use to reflect densities of harbour porpoise within the Array marine mammal study area, as these are based on the most recent data, collected regularly (monthly) over two years and over the specific area of interest. Therefore, a peak seasonal density of 0.648 animals per km$^2$ has been used for Appropriate Assessment (see section 5.1.1 in volume 3, appendix 10.2 of the Array EIA Report for more details regarding the most appropriate density value to be taken forward to the assessment).

#### Conservation objectives

423. The conservation objectives for the Southern North Sea SAC have been jointly developed by the JNCC and Natural England (2019) to ensure that the integrity of the site in maintained and that it makes the best possible contribution to maintaining FCS for harbour porpoise in UK waters. In the context of natural change, this will be achieved by ensuring the following conservation objectives:

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 (JNCC and Natural England, 2019).

424. In the advice on operations for this site, noise disturbance from a project individually or in-combination with others is regarded as significant if it excludes harbour porpoise from more than 20% of the part of the SAC that was designated on the basis of higher persistent densities for a specific season (summer or winter; see paragraph 418) (thereafter referred to as relevant area) in any given day, and an average of 10% of the relevant area of the site over the specific season (JNCC and Natural England, 2019).

425. To assess impacts to Conservation Objective 1 ('harbour porpoise is a viable component of the site'), the Advice on Operations states that the reference population for assessments against this objective is the MU population in which the SAC is situated (JNCC and Natural England, 2019). At the time of writing the Advice on Operations, the most recent MU population for harbour porpoise was from IAMMWG (2015). Given that more recent data are now available, and to align with the approach undertaken in the Array EIA Report, IAMMWG (2022) abundance data have been used for the reference population for harbour porpoise. The estimated abundance for the North Sea MU is 346,601 individuals (IAMMWG, 2022). As described in paragraph 422, it was considered that design-based absolute density estimates from the DAS data were the most appropriate to inform impact assessments, and the absolute density of 0.651 animals per km$^2$ has been taken forward to the assessment in the Array EIA Report and in this Part of the RIAA.

426. Further information on the conservation objectives for the Southern North Sea SAC is provided in JNCC and Natural England (2019). This document lists the following pressures as relevant to the harbour porpoise feature of the SAC:

- removal of non-target species by fisheries, in this case referring to bycatch (and probable mortality) of harbour porpoise;
- contaminants, which may affect harbour porpoise directly, or indirectly via prey and/or habitat contamination;
- anthropogenic underwater noise;
- death or injury from collision with vessels and/or installations; and
- removal of target species, in this case referring to harbour porpoise prey species (JNCC and Natural England, 2019).

#### Condition assessment

427. A condition assessment for harbour porpoise was not provided (JNCC and Natural England (2019), however the status of both the harbour porpoise feature and the SAC itself were presented as 'Favourable' on the JNCC site (JNCC, 2023d).

### 6.2.3. MORAY FIRTH SAC

#### Site description

428. At its closest point, the Moray Firth SAC is located 175.86 km north-west of the site boundary. This SAC covers an area of 1,512 km$^2$ and extends from the inner firths to Helmsdale on the north coast and Lossiemouth on the south coast (JNCC, 2023b). It is designated primarily for bottlenose dolphin, as this SAC supports the only known resident population of bottlenose dolphin in the North Sea (JNCC, 2023b, NatureScot, 2021). Based on data collected in 1980s and early 1990s, the Moray Firth SAC is thought to encompass the core area of occurrence of the resident, coastal population of bottlenose dolphins in the North Sea. The CMA document for this site (NatureScot, 2021) states that the site reference population is between 101 to 250 bottlenose dolphin, which is based on data from 2005. However, more recently Arso Civil *et al.* (2021), published an estimated abundance of 224 individuals based on a five year average between 2015 to 2019.

429. Data from the site condition monitoring suggests that the proportion of population that use the SAC has declined, although the overall population along the coast is increasing (Cheney *et al.*, 2018), and it is thought that their range is extending (Arso Civil *et al.*, 2021, Arso Civil *et al.*, 2019, Cheney *et al.*, 2018, IAMMWG, 2023, Quick *et al.*, 2014).

#### Feature accounts

<u>Bottlenose dolphin</u>

430. Bottlenose dolphin is an odontocete and a member of the family Delphinidae. They are found in temperate and tropical waters worldwide. This species is the largest of the beaked dolphins and ranges in size from 1.9 m to 3.8 m. Bottlenose dolphin can live, on average, between 20 to 30 years. On average, males reach sexual maturity at ten to 12 years and females at five to ten years. Mating occurs during the summer months, with gestation taking 12 months and calves suckling for 18 to 24 months. Females generally reproduce every three to six years (Mitcheson, 2008)

431. The distribution of this species is influenced by factors such as tidal state, weather conditions, resource availability, life cycle stage, or season (Hastie *et al.*, 2004) and there is variation in the patterns of habitat use, even within a population. Typical prey items in Scottish waters include Atlantic salmon, cod, haddock, saithe *Pollachius virens*, and whiting *Merlangius merlangus* (Santos *et al.*, 2001).

432. Bottlenose dolphin are more frequently seen in groups rather than individually, although group size in coastal populations may be smaller than offshore populations. It should be noted that very little is known about offshore populations (Rogan *et al.*, 2018) and this assessment will focus on coastal bottlenose dolphin population. For example, in the northern North Sea, only the coastal population, distributed within the 2 m to 20 m depth contour and approximately 2 km from the shore, is well studied (Geelhoed *et al.*, 2022). Mean group size across the SCANS III survey areas was 5.25 individuals (Hammond *et al.*, 2021). Robinson *et al.* (2017) reported observed group sizes varied between two and 70 animals that in the outer Moray Firth.

433. The Moray Firth SAC is located within the Coastal East Scotland MU for bottlenose dolphin, with the most recent abundance estimate of 224 individuals presented in by the IAMMWG (2022) (based on Arso Civil *et al.* (2019); paragraph 428). However, there were no bottlenose dolphin recorded during site-specific DAS for the Array. SCANS III estimated their offshore abundance for block R (which overlaps with the site boundary) as 1,924 individuals (Hammond *et al.*, 2021). Given that there were no bottlenose dolphin sightings within the block corresponding with the location of the site boundary during the more recent SCANS IV survey, no density values were published (Gilles *et al.*, 2023). Density estimates reported by Lacey *et al.* (2022) are considered the most appropriate to use to reflect densities of bottlenose dolphin in the offshore waters where the site boundary is located and a density of 0.00303 animals per km$^2$ has been

used for Appropriate Assessment (see section 5.1.2 in volume 3, appendix 10.2 of the Array EIA Report for more details regarding the most appropriate density value to be taken forward to the assessment).

Conservation objectives

434. Conservation objectives for the Moray Firth SAC have been developed by NatureScot and are published as part of a CMA document (NatureScot, 2021). The conservation objectives for all features of the SAC are as follows:

- to ensure that the qualifying features of Moray Firth SAC are in favourable condition and make an appropriate contribution to achieving FCS; and
- 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 (NatureScot, 2021).

435. Conservation objectives for bottlenose dolphin are as follows:

- 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; and
- 2c: The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained (NatureScot, 2021).

436. As presented in the CMA for the Moray Firth SAC, bottlenose dolphin are considered sensitive to:

- removal of non-target and target species (i.e. entanglement of bottlenose dolphins in fishing gears as bycatch and removal of their prey species);
- contaminants (e.g. through effects on water quality and bioaccumulation of contaminants that in turn affect survival and productivity rates);
- underwater noise, which may cause marine mammals to relocate, interfere with communication, navigation, foraging, and may disrupt social bonds; and
- death or injury by collision (predominantly in relation to collision with various types of fast moving vessels from commercial shipping to personal leisure craft and potentially from tidal turbines) (NatureScot, 2021).

Condition assessment

437. The condition of bottlenose dolphin was assessed in 2016 as:

- bottlenose dolphin: favourable – maintained (NatureScot, 2021).

438. As the bottlenose dolphin feature is in favourable condition at Moray Firth SAC, NatureScot (2021) states that the conservation objectives seek to maintain this condition.

### 6.2.4. REFERENCE POPULATIONS AND DENSITIES

439. A summary of the different MUs and SMUs, associated reference populations, and densities (animals per km$^2$) used within the this Part of the RIAA are presented in Table 6.3. These were agreed upon with SNCBs. For reference, the MUs and SMUs are illustrated in Figure 6.2.

**Table 6.3: Densities and Reference Populations Used for the Assessment on Designated Sites with Relevant Annex II Marine Mammal Features**

| European Site | Annex II Species | Relevant Management Unit | Population in MU (Number of Animals) | Density (Animals per km$^2$) |
|---|---|---|---|---|
| Berwickshire and North Northumberland SAC | Grey seal | East Scotland SMU and Northeast England SMU | 10,783 + 25,913 = 36,696 (Stevens, 2023) | 0.180 (from Carter *et al.* (2022)) |
| Southern North Sea SAC | Harbour porpoise | North Sea MU | 346,601 (IAMMWG, 2022) | 0.651 (Design-based density estimate from site-specific DAS data) |
| Moray Firth SAC | Bottlenose dolphin | Coastal East Scotland MU | 224 (Arso Civil *et al.*, 2021, IAMMWG, 2022) | 0.00303 (based on Lacey *et al.* (2022)) |

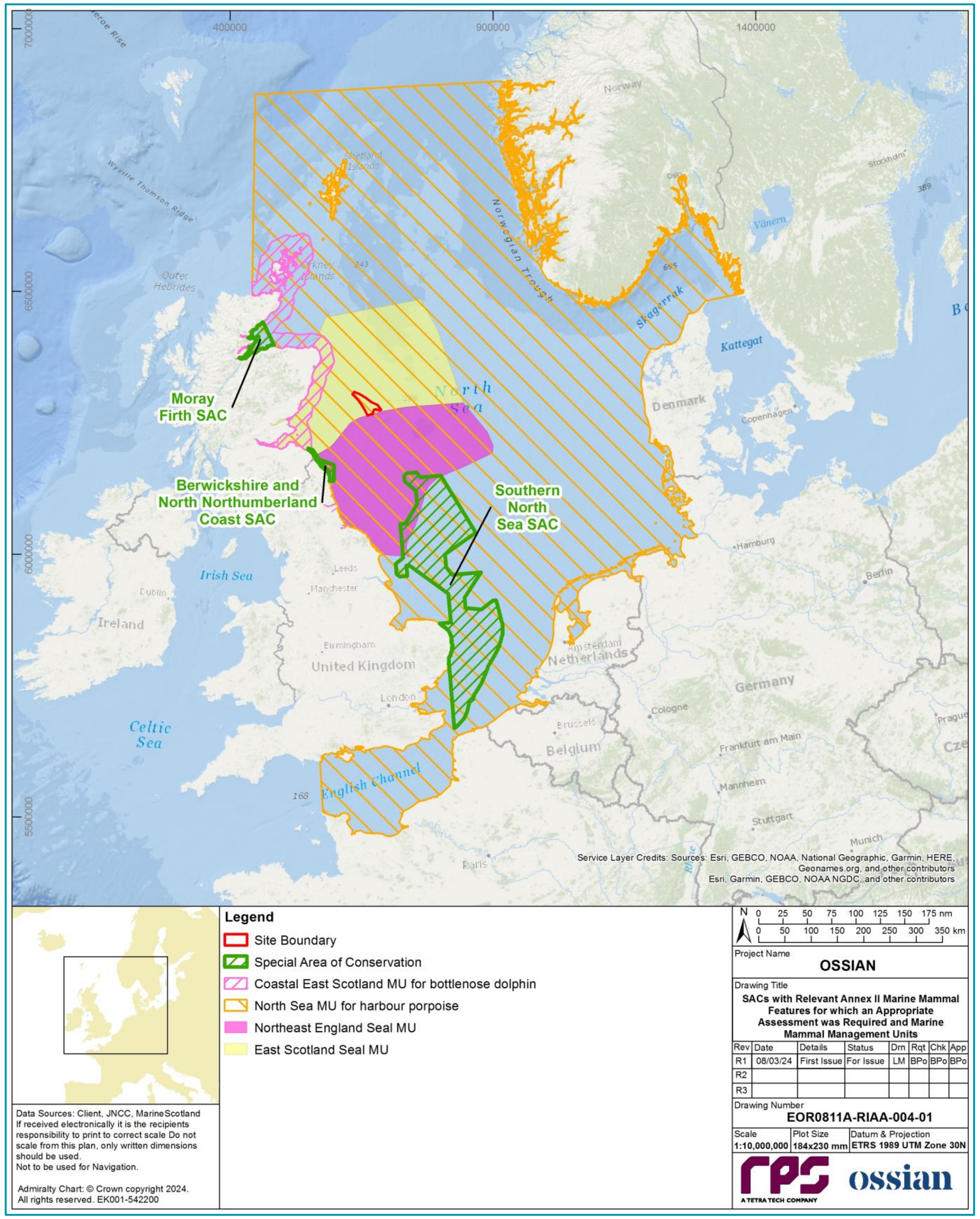


**Figure 6.2: MUs and SMUs Relevant to the Report to Inform Appropriate Assessment**

## 6.2.5. MARINE MAMMALS AND UNDERWATER NOISE

Marine mammals and underwater noise

440. Marine mammals, in particular cetaceans, are capable of generating and detecting noise and are dependent on noise for many aspects of their life, including prey identification, predator avoidance, communication and navigation (Au *et al.*, 1974, Bailey *et al.*, 2010). Increases in anthropogenic noise may consequently lead to a potential effect within the marine environment (Bailey *et al.*, 2010, Parsons *et al.*, 2008). Underwater noise influence may then subsequently affect marine mammals in a number of ways and vary with the distance from the noise source (Marine Mammal Commission, 2007). It can compete with important signals (masking) and alter behaviour (by inducing changes in foraging or habitat-use patterns, separation of mother-calf pairs). Underwater noise can also cause temporary hearing loss or, if the exposure is prolonged or intense, permanent hearing loss. It can also cause damage to tissues other than the ear if noise is sufficiently intense (Marine Mammal Commission, 2007).

441. Given that there is sparse scientific evidence to properly evaluate masking (e.g. no relevant threshold criteria to enable a quantitative assessment), the assessment of impacts associated with underwater noise on marine mammals will consider auditory injury (temporary and permanent hearing loss) and behavioural responses (disturbance).

Injury

442. Auditory injury in marine mammals can be either temporary, also referred to as TTS, where an animal's auditory system recovers over time, or as a Permanent Threshold Shift (PTS), where there is no hearing recovery in the animal. The 'onset' of TTS is deemed to be where there is a 6 dB shift in a hearing threshold, defined by the National Marine Fisheries Service (NMFS, 2016) as a "*the minimum threshold shift clearly larger than any day to day or session to session variation in a subject's normal hearing ability*", and which "*is typically the minimum amount of threshold shift that can be differentiated in most experimental conditions*". The acoustic threshold that would result in the PTS onset in marine mammals have not been directly measured and therefore are extrapolated from available TTS onset measurements. The PTS onset is conservatively considered to occur where there is 40 dB of TTS (Southall *et al.*, 2007).

443. Marine mammals exposed to noise levels that could induce TTS are likely to respond by moving away from (fleeing) the ensonified area and therefore avoiding potential injury. It is considered there is a behavioural response (disturbance) that overlaps with potential TTS ranges. Since derived thresholds for the onset of TTS are based on the smallest measurable shift in hearing, TTS thresholds are likely to be very precautionary and could result in overestimates of TTS ranges. In addition, the conservative assumptions applied in the underwater noise modelling (e.g. use of impulsive noise thresholds at large ranges; see paragraph 462 *et seq*) may also result in the overestimation of ranges.

444. Hastie *et al.* (2019) found that during pile driving there were range dependent changes in signal characteristics with received noise losing its impulsive characteristics at ranges of several kilometres, especially beyond 10 km. Therefore, where TTS ranges exceed 10 km it is not considered a useful predictor of the effects of underwater noise on marine mammals. As such, although TTS ranges were modelled for completeness for all noise-related impacts and are presented in volume 3, appendix 10.1 of the Array EIA Report, these are not included in the assessment of auditory injury presented in this section. Alternatively, the assessment of potential auditory injury is assessed in terms of PTS and accounts for the irreversible nature of the effect.

445. For marine mammals, auditory injury thresholds are based on both $SPL_{pk}$ (i.e. unweighted) and marine mammal hearing-weighted $SEL_{cum}$ as per the latest guidance (Southall *et al.*, 2019). Marine mammal hearing-weighted categories are based on the frequency characteristics (bandwidth and noise level) for each group within which acoustic signals can be perceived and therefore assumed to have auditory effects (Table 6.4). To calculate distances using the $SEL_{cum}$ metric the noise modelling assessment assumed that an animal would be exposed over the duration of the piling activity and that there would be no breaks in

activity during this time. It was assumed that an animal would swim away from the noise source at the onset of activity at a constant rate. The conservative species-specific swim speeds were incorporated into the model (Table 6.5). As a result of the advice received from NatureScot following Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E of the Array EIA Report) (Table 2.1), the assessment of PTS from piling and UXO clearance was based upon the dual metric approach, whereby the maximum injury ranges from $SPL_{pk}$ and $SEL_{cum}$ metrics were used in the assessment. This dual metric approach aligns with the approach presented in the Array EIA Scoping Report (for further information see volume 2, chapter 10 of the Array EIA Report).

**Table 6.4: Summary of PTS Onset Acoustic Thresholds for Relevant Annex II Marine Mammal Hearing Groups**

| Hearing Group | Parameter | Impulsive | Non-impulsive |
|---|---|---|---|
| High Frequency (HF) cetaceans (e.g. bottlenose dolphin) | Peak, dB re 1μPa unweighted | 230 | - |
| | SEL, dB re 1μPa²s HF weighted | 185 | 198 |
| Very High Frequency (VHF) cetaceans (e.g. harbour porpoise) | Peak, dB re 1μPa unweighted | 202 | - |
| | SEL, dB re 1μPa²s VHF weighted | 155 | 173 |
| Phocid Carnivores in Water (PCW) (e.g. grey seal) | Peak, dB re 1μPa unweighted | 218 | - |
| | SEL, dB re 1μPa²s PCW weighted | 185 | 201 |

**Table 6.5: Swim Speeds used in the Underwater Noise Modelling**

| Species | Hearing Group | Swim Speed (m/s) | Source |
|---|---|---|---|
| Harbour porpoise | VHF | 1.5 | Otani *et al.* (2000) |
| Bottlenose dolphin | HF | 1.52 | Bailey *et al.* (2010) |
| Grey seal | PCW | 1.8 | Thompson *et al.* (2015a) |

Disturbance

446. As noise intensity decreases beyond the injury threshold zone, noise levels have the potential to disrupt the behavioural patterns of marine mammals. The reaction of a marine mammal to disturbance is dependent upon individual factors and contextual considerations (Southall *et al.*, 2019). Prior experiences and acclimatisation play crucial roles in determining whether an individual will manifest an aversive response to noise, especially in regions characterised by elevated underwater noise levels associated with human activities.

447. For the purposes of HRA, an area-based or fixed threshold approach is more appropriate for assessment, rather than the dose-response approach used in the EIA (which assumes that not all animals within an impact zone are disturbed) (volume 2, chapter 10 of the Array EIA Report). For example, disturbance for harbour porpoise in SACs is defined through spatial and temporal thresholds set out in the SAC conservation objectives (JNCC and Natural England, 2019), and in this regard an area-based assessment is required to obtain the area of ensonified habitat to a level that may lead to significant disturbance.

448. An unweighted noise threshold value of 143 dB re 1μPa²s $SEL_{ss}$ was recently recommended in the position statement on assessing behavioural disturbance of harbour porpoise from underwater noise published by Natural Resource Wales (NRW, 2023). Acoustic recordings of the pile driving noise were utilised alongside harbour porpoise monitoring to derive a threshold for behavioural reactions to piling noise. Declines were found at noise levels exceeding an unweighted $SEL_{ss}$ of 143 dB re 1 μPa²s and up to 17 km from piling. This means that harbour porpoise may react with avoidance only when exposure exceeds a threshold value of 143 dB re 1 μPa²s. It is worth noting that the noise threshold of 143 dB re 1 μPa²s was derived from a modelled average of six different studies of full-scale pile driving operations and thereby represents a large amount of empirical data (Tougaard, 2021). This threshold is relevant to the HRA process as it is an area-based approach and is therefore similar to the guidance on the use of Effective Deterrence Ranges (EDR) to assess the significance of noise disturbance at harbour porpoise SACs (JNCC, 2020). Although the JNCC (2020) guidance applies to England, Wales, and Northern Ireland, it is still relevant to this assessment as the Southern North Sea SAC lies within English waters. Furthermore, as Natural England provided consultation on the inclusion of the Southern North Sea for Appropriate Assessment (Table 2.1), the EDR approach has been included in the assessment for harbour porpoise as the JNCC (2020) guidance was also produced in collaboration with Natural England. For the assessment of piling and UXO clearance, EDRs of 26 km have been used. This is in line with the guidance for UXO clearance, as only one EDR was presented (JNCC, 2020). For piling, the use of a 26 km EDR follows a precautionary approach, as it represents the largest EDR proposed for different piling techniques (e.g. monopiles or pin piles, and conductor piling for oil and gas wells) (JNCC, 2020). The 26 km EDR for piling is also considered precautionary given the lack of guidance surrounding floating offshore wind developments.

449. Therefore, for harbour porpoise, the derived threshold presented by Tougaard (2021) and the EDRs presented in JNCC (2020) have been used to assess behavioural disturbance from piling to the harbour porpoise feature of the Southern North Sea SAC. There are, however, limited studies to support the derivation of similar thresholds for the other marine mammal species.

450. Therefore, for grey seal and bottlenose dolphin, the NMFS level B harassment threshold (analogous to strong disturbance) of 160 dB re 1 μPa (rms) has been applied for an area-based assessment of impulsive noise sources (such as some site-investigation surveys) (NMFS, 2005).

451. Therefore, for impulsive noise sources other than piling ((e.g. some site-investigation survey techniques), this assessment adopts the NMFS (2005) Level B harassment threshold of 160 dB re 1 μPa (rms) for impulsive noise, which is defined as: *"having the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild".* This definition is similar to the JNCC (2010b) description of non-trivial (significant) disturbance. The United States (US) NMFS (2005) guidelines also suggest a precautionary threshold of 140 dB re 1 μPa (rms) to indicate the onset of low level marine mammal disturbance effects for all mammal groups for impulsive noise, although this is not considered likely to lead to a 'significant' disturbance response and is therefore hereinafter referred to as 'mild disturbance'.

452. The NMFS (2005) guidance sets the marine mammal level B harassment threshold for continuous noise at 120 dB re 1 μPa (rms). This threshold has therefore been adopted in the assessment of impacts as a result of continuous noise, such as non-impulsive site-investigation surveys.

453. A summary of the criteria used throughout to assess disturbance is given in Table 6.6.

**Table 6.6: Summary of Criteria used in the Appropriate Assessment of Disturbance for the Relevant Annex II Marine Mammal Species**

| Noise Source | Species | Approach | Source |
|---|---|---|---|
| Piling | Harbour porpoise | • Unweighted threshold 143 dB re 1 µPa$^2$s SELss<br><br>EDR of 26 km | Tougaard (2021) and JNCC (2020) |
| | Bottlenose dolphin<br>Grey seal | • Unweighted threshold 160 dB re 1 µPa (rms) (strong disturbance)<br><br>Unweighted threshold of 140 dB re 1 µPa (rrms) (mild disturbance) | NMFS (2005) |
| UXO | Harbour porpoise | • Unweighted $SPL_{pk}$ and hearing-weighted $SEL_{cum}$ for TTS as a proxy for disturbance ('fleeing' response)<br><br>EDR of 26 km | Southall *et al.* (2019) and JNCC (2020) |
| | Bottlenose dolphin<br>Grey seal | Unweighted $SPL_{pk}$ and hearing-weighted $SEL_{cum}$ for TTS as a proxy for disturbance ('fleeing' response) | Southall *et al.* (2019) |
| Site investigation surveys (impulse) | All marine mammal species | • Unweighted threshold of 160 dB re 1 µPa (rms) (strong disturbance)<br><br>Unweighted threshold of 140 dB re 1 µPa (rms) (mild disturbance) | NMFS (2005) |
| Site investigation surves (non-impulsive) | All marine mammal species | Unweighted threshold of 120 dB re 1 µPa (rms) | NMFS (2005) |

### Assumptions and limitations

454. By applying the fixed-threshold based criteria, the magnitude of impact can be quantified with respect to the spatial extent of disturbance. However, Southall *et al.* (2021) noted that it is challenging to develop a comprehensive set of empirically derived criteria for such a diverse group of animals. Since there are broad differences in hearing across the frequency spectrum for different marine mammal hearing groups, noises that disturb one species may be irrelevant or inaudible to other species. Variance in responses even across individuals of the same species are well documented to be context and noise-type specific (Ellison *et al.*, 2012). In addition, the potential interacting and additive effects of multiple stressors (e.g. reduction in prey, noise and disturbance, contamination, etc.) is likely to influence the severity of responses (Lacy *et al.*, 2017).

455. As such, the recent recommendations by Southall *et al.* (2021) steer away from a single overarching approach. Instead, the study proposes a framework for developing probabilistic response functions for future studies. The paper suggests different contexts for characterising marine mammal responses for both free-ranging and captive animals with distinctions made by noise sources (i.e. active sonar, seismic surveys, continuous/industrial noise and pile driving). Three parallel categories have been proposed within which a severity score from an acute (discrete) exposure can be allocated:

- survival – defence, resting, social interactions and navigation;
- reproduction – mating and parenting behaviours; and
- foraging – search, pursuit, capture and consumption.

456. Although some studies have been able to assign responses to these categories based on acute exposure, there is still limited understanding of how longer-term (chronic) exposure could translate into population level effects. The potential for behavioural disturbance to lead to population consequences has been considered using the iPCoD approach and is summarised in paragraphs 517 *et seq.*

457. Southall *et al.* (2021) reported observations from long term whale-watching studies and suggested that there were differences in the ability of marine mammals to compensate for long term disturbance which related to their breeding strategy. For example, baleen whales and grey seal, as 'capital breeders', accumulate energy in their feeding grounds and transfer it to calves in their breeding ground, whilst other species such as harbour porpoise and bottlenose dolphin are 'income breeders' as they balance the costs of pregnancy and lactation by increased food intake, rather than depending on fat stores. Reproductive strategy can impact the energetic consequences of disturbance and cause variation in an individual's vulnerability to disturbance based on both its reproductive strategy and stage (Harwood *et al.*, 2020).

458. Marine mammal ability to compensate for chronic exposure to noise will also depend on a range of ecological factors, including the relative importance of the disturbed area and prey availability within their wider home range, the distance to and quality of other suitable sites, the relative risk of predation or competition in other areas, individual exposure history, and the presence of concurrent disturbances in other areas of their range (Gill *et al.*, 2001). Animals may be able to compensate for short term disturbances by feeding in other areas, for example, which would reduce the likelihood of longer-term population consequences. Booth (2019) reported that although minimising the anthropogenic disturbance is an important factor to animal's health, if animals can find suitable high-energy-density prey they may be capable of recovering from some lost foraging opportunities. Christiansen *et al.* (2015) studied the effect of whale-watching on minke whale *Balaenoptera acutorostrata* in Faxafloi Bay, Iceland and found no significant long-term effects on vital rates, although years with low sandeel density led to increased exposure to whale-watching as whales were forced to move into disturbed areas to forage. Odontocetes may be more vulnerable to whale-watching compared to mysticetes (i.e. baleen whales) due to their more localised, and often, coastal home ranges. Bejder *et al.* (2006) documented a decrease in local abundance of bottlenose dolphin which was associated with an increase in whale-watching in a tourist area compared to a control area. Studies of changes in abundance as a result of disturbance should be considered in light of findings presented in Gill *et al.* (2001) who reported that if there is no suitable habitat nearby animals may be forced to remain in an area despite the disturbance, regardless of whether or not it could affect survival or reproductive success.

459. The Annex II marine mammals considered in this assessment vary biologically and therefore have different ecological requirements that may affect their sensitivity to disturbance. This point is illustrated by the differences between marine mammals identified as key biological receptors in the baseline. Grey seals are capital breeders and store energy for reproduction and survival, while harbour porpoise (and other cetaceans whose ecology is well studied, e.g. bottlenose dolphin) are income breeders and they use energy that is acquired on a continual basis, including during the reproductive period (Stephens *et al.*, 2009).

460. Recognising the inherent uncertainty in the quantification of effects using threshold approaches, this assessment has adopted a precautionary approach, consisting of:

- conservative assumptions in the marine mammal baseline (e.g. use of seasonal density peaks for harbour porpoise densities);
- conservative assumptions in the MDS for the project parameters; and
- conservative assumptions in the underwater noise modelling (see volume 3, appendix 10.1 for more details).

461. These assumptions have been referred to throughout this assessment, illustrating that the systematic incorporation of layers of conservatism is likely to result in a very precautionary assessment.

### Conservatism in the Underwater Noise Modelling

462. Continuing on from the information presented in paragraphs 454 to 461, a number of conservative assumptions were adopted in the underwater noise model. These measures of conservatism are summarised in this section and highlight that both PTS and TTS onset ranges predicted using the $SEL_{cum}$ threshold are likely to lead to overestimates in the ranges and therefore should be interpreted with caution.

463. The underwater noise modelling assumed that the maximum hammer energy would be reached and maintained at all locations, whereas this is unlikely to be the case based on examples from other offshore wind farms, e.g. Beatrice Offshore Wind Farm, where the mean actual hammer energy averages were considerably lower than the maximum assessed in the Environmental Statement and only six out of 86 asset locations reached maximum hammer energy (Beatrice Offshore Wind Farm Limited, 2018).

464. Additionally, the piling procedure simulated in the model does not allow for short pauses in piling (e.g. for realignment) and therefore the modelled $SEL_{cum}$ is likely to be an overestimate since, in reality, these pauses will reduce the noise exposure that animals experience whilst moving away.

465. The underwater noise modelling assessment also assumed that animals swim directly away from the noise source at constant and conservative average speeds based on published values. Whilst this buffers the uncertainty with respect to the directionality of their movement, it may lead to overestimates of the potential range of effect as animals are likely to exceed these speeds. For example, Otani *et al.* (2000) reported horizontal speed for harbour porpoise can be significantly faster than vertical speed and cite a maximum speed of 4.3 m/s (compared to 1.5 m/s used in the underwater noise model).

466. The underwater noise model accounts for the $SEL_{cum}$ metric as an equal-energy rule, where exposures of equal-energy are assumed to produce the same noise-induced threshold shift regardless of how the energy is distributed over time. Since for intermittent noise (such as piling) the quiet periods between noise exposures will allow some recovery of hearing compared to continuous noise, the equal-energy rule is likely to overestimate the extent of impact. Additionally, modelling of concurrent piling assumed piling will exactly coincide and strike piles simultaneously, whereas in reality this is highly unlikely and could lead to overestimates in the injury and/or disturbance ranges.

467. The impulsive noise is likely to undergo transition into non-impulsive noise at distance from the noise source due to a combination of factors (e.g. dispersion of the waveform, multiple reflections from sea surface and seafloor, and molecular absorption of high frequency energy). The empirical evidence suggest that such shifts in impulsivity could occur within 10 km from the noise source (Hastie *et al.*, 2019). However, since the precise range at which this transition occurs is unknown, the underwater noise model adopted the impulsive thresholds at all ranges. This is likely to lead to an overly precautionary estimate of injury ranges at larger distances (tens of kilometres) from the noise source.

### Sensitivities of marine mammals to underwater noise

#### Harbour porpoise

#### Injury

468. Scientific understanding of the biological effects of threshold shifts is limited to the results of controlled exposure studies on small numbers of captive animals (reviewed in Finneran (2015)) where TTS are experimentally induced (given it is unethical to induce PTS in animals) and thresholds for PTS extrapolated using TTS growth rates. Kastelein *et al.* (2013) demonstrated that hearing impairment as a result of exposure to piling noise is likely to occur where the source frequencies overlap the range of peak sensitivity for the receptor species, rather than across the whole frequency hearing spectrum. The study demonstrated that for simulated piling noise (broadband spectrum), harbour porpoise hearing around 125 kHz (the key frequency for echolocation) was not affected. Rather, a measurable threshold shift in hearing was induced at frequencies of 4 kHz to 8 kHz, noting the magnitude of the hearing shift was relatively small (2.3 dB to 3.6 dB at 4 kHz to 8 kHz) due to the lower received SELs at these frequencies. This was due to most of the energy from the simulated piling occurring in lower frequencies (Kastelein *et al.*, 2013). Kastelein *et al.* (2017) confirmed sensitivity declined sharply above 125 kHz in a following study.

469. The duty cycle of fatiguing noises is also likely to affect the magnitude of a hearing shift, (e.g. hearing may recover to some extent during inter-pulse intervals (Kastelein *et al.*, 2014)). Other studies reported that whilst a threshold shift can accumulate across multiple exposures, the resulting shift will be less than the shift from a single, continuous exposure with the same total SEL (Finneran, 2015).

470. In order to reduce exposure to noise, cetaceans are able to undertake some self-mitigation measures (e.g. the animal can change the orientation of its head so that noise levels reaching the ears are reduced), or it can suppress hearing sensitivity by one or more neurophysiological auditory response control mechanisms in the middle ear, inner ear, and/or central nervous system. Kastelein *et al.* (2020) highlighted the lack of reproducibility of TTS in a harbour porpoise after it was exposed to repeated airgun noises, and suggested self-mitigation may lead to the discrepancies.

471. It is important to highlight that extrapolating the results from captive bred studies to how animals may respond in the natural environment should be treated with caution as there are discrepancies between experimental and natural environmental conditions. In addition, the small number of test subjects does not account for intraspecific differences (i.e. differences between individuals) or interspecific differences (i.e. extrapolating to other species) in response. However, based on the latest scientific evidence, PTS is a permanent and irreversible hearing impairment. It is therefore anticipated that harbour porpoise is sensitive to this effect as the loss of hearing would affect key life functions (such as mating and maternal fitness, communication, foraging, predator detection) and could lead to a change in an animal's health (chronic) or vital rates (acute) (Erbe *et al.*, 2018). In addition to studies conducted in controlled environments, there is also evidence on noise-induced hearing loss, based on inner ear analysis in a free-ranging harbour porpoise (Morell *et al.*, 2021). Considering the above, a potential consequence of a disruption in key life functions is that the health of impacted animals would deteriorate and potentially lead to reduced birth rate in females and mortality of individuals (Costa, 2012).

#### Behavioural disturbance

472. As a small cetacean species, harbour porpoise is vulnerable to heat loss through radiation and conduction. They have a high metabolic requirement, with a need to forage frequently to lay down sufficient fat reserves for insulation. Kastelein *et al.* (1997) found in a study of six, non-lactating, harbour porpoise that they require between 4% and 9.5% of their body weight in fish per day. In the wild, porpoises forage almost continuously day and night to achieve their required calorific intake (Wisniewska *et al.*, 2016), meaning they are vulnerable to starvation if foraging is interrupted.

473. It is well documented that there is variance in behavioural responses to increased underwater noise and it is context specific. Factors such as the activity state of the receiving animal, the nature and novelty of the noise (i.e. previous exposure history), and the spatial relation between noise source and receiving animal are important in determining the likelihood of a behavioural response and therefore their sensitivity (Ellison *et al.*, 2012). Empirical evidence from monitoring at offshore wind farms during construction suggests that pile driving is unlikely to lead to 100% avoidance of all individuals exposed, and that there will be a proportional decrease in avoidance at greater distances from the pile driving source (Brandt *et al.*, 2011). Graham *et al.* (2019) demonstrated this dose-response at Horns Rev Offshore Wind Farm, where 100% avoidance occurred in harbour porpoises at up to 4.8 km from the piles, whilst at greater distances (10 km plus) the proportion of animals displaced reduced to < 50%). More recently Graham *et al.* (2019) studied responses of harbour porpoise to piling at the Beatrice Offshore Wind Farm, and suggested that harbour porpoise may adapt to increased noise disturbance over the course of the piling phase, thereby showing a degree of tolerance and behavioural adaptation. Graham *et al.* (2019) also demonstrated that the probability of occurrence of harbour porpoise (measured as porpoise positive minutes) increased exponentially moving further away from the noise source. Similarly, a study of seven offshore wind farms constructed in the German Bight demonstrated that detections of harbour porpoise declined several hours before the start of pling within the vicinity (up to 2 km) of the construction site and were reduced for about

one to two hours post-piling (Brandt *et al.*, 2018). At the maximum effect distances (from 17 km out to approximately 33 km) avoidance only occurred during the hours of piling. Brandt *et al.* (2018) found harbour porpoise detections during piling resulted in a measurable response at noise levels exceeding 143 dB re 1 μPa$^2$s and at lower received levels (i.e. at greater distances from the source) there was little evident decline in porpoise detections. These studies demonstrate the dose-response relationship between received noise levels and declines in porpoise detections although noting that the extent to which responses could occur will be context specific such that, particularly at lower received levels (i.e. 130 to 140 dB re 1 μPa$^2$s), detectable responses may not be apparent from region to region.

474. Building on earlier work presented in Southall *et al.* (2007) and the mounting literature in this area, Southall *et al.* (2021) introduced a concept of behavioural response severity spectrum with progressive severity of possible responses within three response categories: survival (e.g. resting, navigation, defence), feeding (e.g. search, consumption, energetics), and reproduction (e.g. mating, parenting). For example, at the point of the spectrum rated seven to nine (where sensitivity is highest) displacement is likely to occur resulting in movement of animals to areas with an increased risk of predation and/or with sub-optimal feeding grounds. A failure of vocal mechanisms to compensate for noise can result in interruption of key reproductive behaviour including mating and socialising, causing a reduction in an individual's fitness leading to potential breeding failure and impact on survival rates.

475. There are limitations of the single step-threshold approach for strong disturbance and mild disturbance as it does not account for inter-, or intraspecific variance or context-based variance. However, according to Southall *et al.* (2021) harbour porpoise within the area modelled as 'strong disturbance' would be most sensitive to behavioural effects and therefore may have a response score of seven or above. Mild disturbance (score four to six) could lead to effects such as changes in swimming speed and direction, minor disruptions in communication, interruptions in foraging, or disruption of parental attendance/nursing behaviour (Southall *et al.*, 2021). Therefore, at the lower end of the behavioural response spectrum, the potential severity of effects is reduced and whilst there may be some detectable responses that could result in effects on the short-term health of animals, these are less likely to impact on the survival rate of the animal.

476. Although harbour porpoise may be able to avoid the disturbed area and forage elsewhere, there may be a potential effect on reproductive success of some individuals. As aforementioned, it is anticipated that there would be some adaptability to the elevated noise levels from piling and therefore survival rates are not likely to be affected. The assessment is highly conservative due to uncertainties associated with the effects of behavioural disturbance on vital rates of harbour porpoise, as it assumes the same level of sensitivity for both strong and mild disturbance, noting that for the latter the sensitivity is likely to be lower.

<u>Bottlenose dolphin</u>

<u>Injury</u>

477. Individual dolphins experiencing PTS would suffer a biological effect that could impact the animal's health and vital rates (Erbe *et al.*, 2018). Bottlenose dolphin are classed as HF cetaceans (Southall *et al.*, 2019). As described for harbour porpoise, there are frequency-specific differences in the onset and growth of a noise-induced threshold shift in relation to the characteristics of the noise source and hearing sensitivity of the receiving species. For example, exposure of two captive bottlenose dolphins to an impulsive noise source between 3 kHz and 80 kHz found that there was increased susceptibility to auditory fatigue between frequencies of 10 to 30 kHz (Finneran *et al.*, 2013).

<u>Behavioural disturbance</u>

478. Bottlenose dolphin are thought to be less vulnerable to the effects of disturbance than harbour porpoise; with larger body sizes – and lower metabolic rates – the necessity to forage frequently is lower in comparison. Bottlenose dolphin is largely coastally distributed in relation to the Array marine mammal study area and are more abundant during spring and summer compared to autumn and winter months (Paxton *et al.*, 2016).

479. Limited information is available regarding the specific sensitivities of bottlenose dolphin as most studies have concentrated on harbour porpoise. A study of the response of bottlenose dolphin to piling noise during harbour construction works at the Nigg Energy Park in the Cromarty Firth (north-east Scotland) found that there was a measurable (albeit weak) response to impact and vibration piling with animals reducing the amount of time they spent in the vicinity of the construction works (Graham *et al.*, 2017). Another study investigating dolphin detections in the Moray Firth during impact piling at the Moray East and Beatrice Offshore Wind Farms found surprising results at small temporal scales with an increase in dolphin detections on the southern Moray coast on days with impulsive noise compared to days without (Fernandez-Betelu *et al.*, 2021). Predicted maximum received levels in coastal areas were 128 dB re. 1 μPa$^2$s and 141 dB re. 1 μPa$^2$s during piling at Beatrice Offshore Wind Farm Ltd and Moray Offshore Wind Farm Ltd, respectively (Fernandez-Betelu *et al.*, 2021). The authors of this study warn that caution must be exercised in interpreting these results as increased click changes do not necessarily equate to larger groups sizes but may be due to a modification in behaviour (e.g. an increase in vocalisations during piling). The results, however, do suggest that impulsive noise generated during piling at the offshore wind farms did not cause any displacement of bottlenose dolphins from their population range. Notably, the received levels during piling at Moray Offshore Wind Farm are higher than those predicted for the outer isopleths (130 dB and 135 dB re. 1 μPa$^2$s) that overlap with the Coastal East Scotland MU during piling at the Array, suggesting that disturbance at these lower noise levels is unlikely to lead to displacement effects.

<u>Grey seal</u>

<u>Injury</u>

480. In comparison to cetaceans, seals are less dependent on hearing for foraging, but may rely on noise for communication and predator avoidance (e.g. Deecke *et al.*, 2002). Seals can detect swimming fish with their vibrissae (Schulte-Pelkum *et al.*, 2007) but, in certain conditions, they may also listen to noises produced by vocalising fish in order to hunt for prey. Consequently, the ecological consequences of a noise-induced threshold shift in seals may be a reduction in fitness, reproductive output and longevity (Kastelein *et al.*, 2018b). A study by Hastie *et al.* (2015a) reported that, based on calculations of SEL of tagged harbour seals during the construction of the Lincs Offshore Wind Farm (Greater Wash, UK), at least half of the tagged seals would have received noise levels from pile driving that exceeded auditory injury thresholds for pinnipeds (PTS). Nevertheless, population estimates indicated that the relevant population trend was increasing and therefore (whilst there are many other ecological factors that will influence the population health) this indicated that predicted levels of PTS did not affect a sufficient numbers of individuals to cause a decrease in the population trajectory (Hastie *et al.*, 2015b). Hastie *et al.* (2015a) did note that the paucity of data on effects of noise on seal hearing means the exposure criteria used are intentionally conservative and therefore predicted numbers of individuals likely to be affected by PTS would also have been highly conservative.

481. Reichmuth *et al.* (2019) reported the first confirmed case of PTS following a known acoustic exposure event in a seal. The study evaluated the underwater hearing sensitivity of a trained harbour seal before and immediately following exposure to 4.1 kHz tonal fatiguing stimulus ($SPL_{rms}$ was increased from 117 to 182 dB re 1 μPa). Rather than the expected pattern of TTS onset and growth, an abrupt threshold shift of >47 dB (i.e. the difference between the pre-exposure and post-exposure hearing thresholds in dB) was observed half an octave above the exposure frequency. Hearing at 4.1 kHz recovered within 48 hours, however, there was a PTS of at least 8 dB at 5.8 kHz, and hearing loss was evident for more than ten years.

482. Despite the uncertainty in the ecological effects of PTS on seals, seals rely on hearing much less than cetaceans and therefore would exhibit some tolerance (i.e. the effect is unlikely to cause a change in either reproduction or survival rates). In addition, it has been proposed that seals may be able to self-mitigate

(i.e. reduce their hearing sensitivity in the presence of loud noises in order to reduce their perceived SPL) (Kastelein *et al.*, 2018b). Although this evidence suggests a lower sensitivity of pinnipeds to PTS, a precautionary approach has been taken within this assessment due to the potential for uncertainties surrounding their lower sensitivity to PTS.

Behavioural disturbance

483. Mild disturbance has the potential to disturb seals, however this constitutes only slight changes in behaviour, such as changes in swimming speed or direction, and is unlikely to result in population-level effects. Although there are likely to be alternative foraging sites, barrier effects could either prevent seals from travelling to forage from haul-out sites or force seals to travel greater distances than is usual. Strong disturbance could result in displacement of seals from an area.

484. Hastie *et al.* (2021) measured the relative influence of perceived risk of a noise (silence, pile driving, and a tidal turbine) and prey patch quality (low density versus high density), in grey seal in an experimental pool environment. The study found foraging success was highest under relatively silent conditions. When noise from tidal turbines and pile driving was introduced, foraging success remained similar to silent conditions when subjected to prey density was high. When exposed to tidal turbine and pile driving noise, the foraging success at low-density prey conditions was significant reduced. Therefore, avoidance rates were dependent on prey densities as well as the perceived risk from the anthropogenic noise and therefore it can be anticipated such decisions are consistent with a risk/profit balancing approach.

485. Seal behaviour during offshore wind farm installation has been studied based on empirical data (Russell *et al.*, 2016). Movements of tagged harbour seal during piling at the Lincs Offshore Wind Farm in the Greater Wash showed significant avoidance of the offshore wind farm by harbour seal (Russell *et al.*, 2016). Within this study, seal abundance significantly reduced from the piling activity over a distance of up to 25 km and there was a 19% to 23% decrease in usage within this range. Nevertheless, displacement was limited to pile driving activity only, and harbour seal returned rapidly to baseline levels of activity within two hours of cessation of the piling (Russell *et al.*, 2016). More recently, a study by Whyte *et al.* (2020) used tracking data from 24 harbour seal to estimate the potential effects of pile driving noise on this species. Predicted cumulative sound exposure levels ($SEL_{cum}$) experienced by each seal were compared to different auditory weighting functions and thresholds for TTS and PTS. The study used predictions of seal density during pile driving made by Russell *et al.* (2016) compared to distance from the wind farm and predicted single-strike sound exposure levels ($SEL_{ss}$) by multiple approaches. Predicted seal density significantly decreased within 25 km or $SEL_{ss}$ (averaged across depths and pile installations) above 145 dB re 1 μPa$^2$s. Predictions of seal density, and changes in seal density, during piling were given in Table V in Whyte *et al.* (2020), averaged across all water depths and piling events.

486. Diverse reactions of tracked grey seal to pile driving during construction of the Luchterduinen and Gemini wind farms was reported in Aarts *et al.* (2018). Reactions ranged from altered surfacing and diving behaviour, changes in swimming direction, or coming to a halt. In some cases, however, no apparent changes in diving behaviour or movement were in Aarts *et al.* (2018). Similar to the conclusions drawn by Hastie *et al.* (2021), the study at the Luchterduinen and Gemini wind farms indicated animals were balancing risk (disturbance) with profit (prey). Approximately half of the tracked grey seal were absent from the pile driving area altogether, but this may be because animals were drawn to other more profitable areas as opposed to active avoidance of the noise, although a small sample size (n = 36 animals) means that no firm conclusions could be reached. It was notable that, in some cases, grey seal exposed to pile driving at distances shorter than 30 km returned to the same area on subsequent trips suggesting that the incentive to go to the area was stronger than potential deterrence effect of underwater noise from pile driving in some animals.

487. Changes in behaviour and subsequent barrier effects have the potential to affect the ability of phocid seals to accumulate the energy reserves prior to both reproduction and lactation (Sparling *et al.*, 2006). Female seals increase their foraging effort (including increased diving behaviour) before the breeding season, maximising energy allocation to reproduction. Especially during the third trimester of pregnancy, grey seal accumulate reserves of subcutaneous blubber which they use to synthesise milk during lactation (Hall *et al.*, 2009). Therefore, grey seal foraging at-sea may be most vulnerable in this period, as maternal energy storage is extremely important to offspring survival and female fitness (Ailsa J *et al.*, 2001, Mellish *et al.*, 1999). Potential exclusion from foraging grounds during this time could affect reproduction rates and probability of survival.

488. Phocid seals may also be vulnerable to disturbance during the lactation period, depending on the breeding strategy of a particular species. The lactation period for grey seal is shorter than for harbour seal, lasting around 17 days (Sparling *et al.*, 2006) with females remaining mostly on shore, fasting. Furthermore, as grey seal females do not forage often during lactation, it is expected that they may exhibit some tolerance to disturbance as they would not spend as much time at-sea, where they can be affected by underwater noise. Following lactation however female grey seal return to the water and must forage extensively to build up lost energy reserves. Consequences of disturbance may include reduced fecundity, reduced fitness, and reduced reproductive success. Although grey seal may be able to avoid the disturbed area and forage elsewhere, there may be an energetic cost to having to move greater distances to find food, and therefore there may be a potential effect on reproductive success of some individuals.

## 6.3. ASSESSMENT OF THE ADVERSE EFECTS OF THE ARRAY ALONE

### 6.3.1. UNDERWATER NOISE GENERATED DURING PILING

489. The LSE[2] assessment during the HRA Stage One process identified that during the construction phase, LSE[2] could not be ruled out for underwater noise generated during piling. This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

490. The MDS and designed in measures considered for the assessment of underwater noise generated during piling are shown in Table 6.7 and Table 6.8, respectively. Underwater noise modelling was undertaken using the MDS as outlined in Table 6.7, with the detail of the assessment provided in volume 3, appendix 10.1 of the Array EIA Report.

Table 6.7: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Underwater Noise Generated During Piling in the Construction Phase

| Project Phase | MDS | Justification |
| --- | --- | --- |
| Construction | Wind turbines:<br><br>• up to 265 14 MW semi-submersible floating wind turbine foundations with up to 6 anchors per foundation and one 4.5 m diameter pile per anchor (1,590 piles);<br>• absolute maximum scenario is for 100% of piles to be driven piles;<br>• maximum hammer energy of up to 3,000 kJ;<br>• up to 2 vessels piling concurrently at floating wind turbine anchors;<br>• minimum 950 m and maximum 30 km distance (as based on the MDS presented in volume 3, appendix 10.1 of the Array EIA Report) between concurrent piling events;<br>• up to 8 hours maximum piling per pile, therefore 3 piles installed over 24 hours;<br>• total duration of piling of 12,720 hours over 530 days; and<br>• total piling phase at floating wind turbine anchors of 63 months over a period of 7 years (within the 8 years construction period).<br><br>OSPs:<br><br>• up to 3 large and 12 small jacket foundations with up to 12 and 6 legs per foundation, respectively; 24 x 4.5 m (large jacket) and 12 x 3.0 m (small jacket) diameter piles per leg (216 piles);<br>• maximum hammer energy of up to 4,400 kJ;<br>• only 1 vessel piling at any one time at OSP locations;<br>• up to 8 hours maximum piling per pile, therefore 3 piles installed over 24 hours;<br>• total duration of piling of 1,728 hours over 72 days; and<br>• total piling phase at OSP foundations of 72 months over a period of 8 years.<br><br>There is a potential for 2 vessels piling concurrently at either 2 wind turbine anchor locations or 1 wind turbine anchor and 1 OSP foundation. There may be up to 602 days in which piling may occur within the piling phase at floating wind turbine anchors and OSPs. | For the maximum spatial scenario concurrent piling events would lead to the largest spatial extent of ensonification at any one time. Note that maximum design scenario assumes concurrent piling for wind turbine anchors but it may occur as a combination of wind turbine anchor and OSP foundation.<br><br>The maximum temporal scenario was assessed on the greatest number of days on which piling could occur based on the maximum duration of piling per pile (8 hours) and a single vessel. In total, a maximum of 2 piling vessels will be piling at any one time (either at two wind turbine anchor locations or at wind turbine anchor and OSP).<br><br>Minimum spacing between concurrent piling represents the highest risk of injury to animals as noise from adjacent foundations could combine to produce a greater radius of effect compared to a single piling event. Maximum spacing between concurrent piling represents the highest risk of behavioural effects to marine mammals as a larger area would be ensonified at any one time. |

**Table 6.8: Designed In Measures Considered for the Assessment of Potential Impacts to Annex II Marine Underwater Noise Generated During Piling in the Construction Phase**

| Designed In Measures | Justification | How the Designed In Measure will be Secured |
|---|---|---|
| The development of and adherence to a Piling Strategy (PS) (or equivalent) which will set out the following measures.<br><br>Implementation of initiation stage and soft start during piling. This will involve the use of a low hammer energy with a low number of strikes used initially, followed by lower hammer energies at a higher strike rate at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels:<br>• For anchor piles, a 1 minute initiation phase will be used with hammer energy of 450 kJ at a strike rate of 10 per minute and then soft start duration is 20 minutes with hammer energy of 450 kJ with strike rate of 30 strikes per minute. A ramp up procedure will then increase from 450 kJ to 3,000 kJ with strike rate of 30 strikes per minute for 30 minutes.<br>• For OSP jacket piles, a 1 minute initiation phase will be used with hammer energy of 660 kJ at a strike rate of 10 strikes per minute and then soft start duration is 20 minutes with hammer energy of 660 kJ with strike rate of 30 per minute. A ramp up procedure will then increase from 660 kJ to 4,400 kJ with strike rate of 30 strikes per minute for 30 minutes. | These measures will reduce the likelihood of injury from elevated underwater noise to marine life in the immediate vicinity of piling operations as far as practicable, allowing individuals to move away from the area before sound levels reach a level at which injury may occur.<br><br>These measures will reduce the likelihood of injury from elevated underwater noise to marine mammals in the immediate vicinity of piling operations as far as practicable, allowing individuals to move away from the area before sound levels reach a level at which injury may occur. This is in line with the most up to date guidance for piling/UXO clearance operations (JNCC, 2010a; JNCC, 2010b) and, in most cases, compliance with this guidance reduce the likelihood of injury to marine mammal receptors to negligible levels. | Secured in the Section 36 Consent and/or Marine Licence via the requirement for a PS which will be submitted to MD-LOT for approval.<br><br>The PS (or equivalent) will be submitted post-consent in collaboration with stakeholders, including but not limited to, MD-LOT and NatureScot, following collation of additional data and final design parameters (e.g. piling locations, hammer energies). Noise modelling will be reviewed with the additional information and inform the final PS, which will be submitted to MD-LOT, following consultation with stakeholders |
| The development of and adherence to a Marine Mammal Mitigation Plan (MMMP) (see volume 4, appendix 22 of the Array EIA Report). | The MMMP will:<br>• mitigate for the risk of permanent auditory injury to marine mammals within a pre-defined 'mitigation zone' for each activity. The mitigation zone is determined considering the largest injury zone across all species for each relevant activity;<br>• reduce the potential injury to, marine mammals and other marine megafauna (e.g. basking shark and sea turtles) as far as practicable; and detail the visual and acoustic monitoring required as a minimum over the defined mitigation zones so that animals are clear before the activity commences. Additional measures to deter animals from injury risk zones may be applied in some instances (e.g. ADD or soft start charges).<br><br>An outline MMMP has been developed on the basis of the most recent published statutory guidance (JNCC, 2010a, JNCC, 2010c, JNCC, 2017). | Secured in the Section 36 Consent and/or Marine Licence via the requirement for a PS and associated MMMP which will be submitted to MD-LOT for approval. |

Information to support the assessment

Overview of underwater noise modelling conducted for the Array

491. Pile driving during the construction phase of the Array has the potential to result in higher levels of underwater noise when compared to background levels and could result in auditory injury and/or potential behavioural effects on Annex II marine mammal features of the three SACs identified for Appropriate Assessment. A detailed underwater noise modelling assessment was carried out to investigate the potential for such effects to occur, using the latest assessment criteria (see volume 3, appendix 10.1 of the Array EIA Report).

492. As recommended by stakeholders during the pre-Scoping workshop, only the $SPL_{pk}$ has been used to inform the appropriate mitigation zone, although both metrics ($SPL_{pk}$ and $SEL_{cum}$) are presented in the assessment of PTS for the Array. During piling, with respect to the $SPL_{pk}$ metric, the soft start initiation is the most relevant period, as this is when animals may potentially experience injury from underwater noise emitted by the initial strike of the hammer, after which point it is assumed that they will move away from the noise source. However, to ensure a precautionary approach, the injury ranges for $SPL_{pk}$ are based on the noise from the maximum hammer energy over the entire installation.

493. The scenarios modelled were based on the maximum hammer energies (of 3,000 kJ or 4,400 kJ, see Table 6.7) over the longest possible duration, noting that piling is unlikely to reach and maintain the absolute maximum hammer energy at all locations. The assessment of potential effects on Annex II marine mammals from piling considered a maximum spatial and maximum temporal scenario (Table 6.7).

494. Maximum spatial scenarios assume concurrent piling of piles at OSPs and wind turbine (anchors), leading to the largest area of effect at any one time. Maximum temporal scenarios, leading to the greatest number of days of piling, is based on single piling of piles at wind turbines (anchors) and OSPs (jackets) (Table 6.7).

495. Underwater noise modelling modelled concurrent piling at:

- wind turbines (anchors) with a maximum hammer energy of 3,000 kJ; and
- wind turbine and OSP with a maximum hammer energy of 3,000 kJ and 4,400 kJ, respectively.

496. For the concurrent piling scenario, the following assumptions were identified:

- minimum separation distance of 950 m between concurrent piling events as a maximum design scenario for potential injury; and
- maximum separation distance of up to 30 km as a maximum design scenario for potential disturbance based on the PDE and site bathymetry (Table 6.7).

497. The modelled locations were species-specific, e.g. those that were likely to generate noise contours with the highest potential to overlap with sensitive areas for a given species (e.g. density hotspots). The modelling locations were as follows:

- a point at the northern end of the site boundary (single piling) as well as at the northern end and the central point of the site boundary (concurrent piling) to capture potential overlap with the coastal distribution of bottlenose dolphin; and
- a point at the southern end of the site boundary (single piling) as well as the southern end and the central point of the site boundary (concurrent piling) to assess potential effects on grey seal density hotspots within the Berwickshire and North Northumberland Coast SAC and the Southern North Sea SAC designated for harbour porpoise.

498. For the maximum temporal scenario the assessment focused on the longest duration of piling and the greatest number of days over which piling could occur. The longest duration of piling per pile for wind turbines (anchors) or OSPs (jackets) is eight hours per pile. Therefore, conservatively, the assessment assumes that piling activities can take place over a maximum of 602 days (530 days at wind turbines and 72 days at OSPs) (Table 6.7).

Injury

499. The maximum spatial effect was predicted for concurrent piling at wind turbines and OSPs with a hammer energy of 3,000 kJ and 4,400 kJ, respectively (Table 6.9). Whilst the effect of PTS is considered to result in permanent injury to animals, the risk of animals being exposed to noise levels leading to auditory injury would occur during piling only. As shown in Table 6.7, piling will be intermittent over an eight-year construction piling phase and will occur up to a maximum of 602 days.

500. The instantaneous injury (based on $SPL_{pk}$ metric with no ADD) could occur out to a maximum range of 1,600 m across all species during single pile installation at OSPs, with the maximum range predicted for harbour porpoise (Table 6.9). Considering cumulative exposure using the $SEL_{cum}$ metric, the risk of PTS was not exceeded for bottlenose dolphin or grey seal, but extended to 10 m and 70 m for harbour porpoise (Table 6.9).

501. The maximum spatial effect was estimated using two different concurrent piling scenarios, at wind turbines with a hammer energy of 3,000 kJ with either another wind turbine with a hammer energy of 3,000 kJ or with an OSP with hammer energy of 4,400 kJ (Table 6.10). Given that the potential injury range for the concurrent scenarios based on the $SPL_{pk}$ metric remain the same as the injury ranges for the single installation scenario (as detailed in volume 3, appendix 10.1 of the Array EIA Report) (Table 6.9), these were omitted from the results presented in Table 6.10 and are as presented in paragraph 500. Considering cumulative exposure using the $SEL_{cum}$ metric, the risk of PTS was not exceeded for bottlenose dolphin or grey seal and was estimated to occur out to a maximum range of 203 m for harbour porpoise during concurrent pile installation at wind turbine and OSP (Table 6.10).

**Table 6.9: Summary of PTS Ranges for Single Pile Installation at Wind Turbines (3,000 kJ) and OSPs (4,400 kJ) Using Both Metrics – $SPL_{pk}$ and $SEL_{cum}$ (N/E = threshold not exceeded)**

| Species (Hearing Group) | Metric | Threshold | Potential PTS range (m) | |
|---|---|---|---|---|
| | | | 3,000 kJ (Wind Turbines) | 4,400 kJ (OSPs) |
| Harbour porpoise (VHF) | $SPL_{pk}$ | 202 dB re 1 µPa | 665 | 1,600 |
| | $SEL_{cum}$ | 155 dB re 1 µPa$^2$s | 10 | 70 |
| Bottlenose dolphin (HF) | $SPL_{pk}$ | 230 dB re 1 µPa | 95 | 171 |
| | $SEL_{cum}$ | 185 dB re 1 µPa$^2$s | N/E | N/E |
| Grey seal (PCW) | $SPL_{pk}$ | 218 dB re 1 µPa | 192 | 379 |
| | $SEL_{cum}$ | 185 dB re 1 µPa$^2$s | N/E | N/E |

**Table 6.10: Summary of PTS Ranges for Concurrent Pile Installation at Wind Turbines (3,000 kJ) and at Wind Turbines (3,000 kJ) and OSPs (4,400 kJ) Using $SEL_{cum}$ (N/E = threshold not exceeded)**

| Species (Hearing Group) | Metric | Threshold | Potential PTS range (m) | |
|---|---|---|---|---|
| | | | 3,000 kJ (Wind Turbines) | 3,000 kJ (Wind Turbines) and 4,400 kJ (OSPs) |
| Harbour porpoise (VHF) | $SEL_{cum}$ | 155 dB re 1 µPa$^2$s | 11 | 203 |
| Bottlenose dolphin (HF) | $SEL_{cum}$ | 185 dB re 1 µPa$^2$s | N/E | N/E |
| Grey seal (PCW) | $SEL_{cum}$ | 185 dB re 1 µPa$^2$s | N/E | N/E |
| Given that the potential injury range for the concurrent scenarios based on the $SPL_{pk}$ metric remain the same as the injury ranges for the single installation (Table 6.9), these were omitted from the results presented in this table. | | | | |

502. An MMMP will be implemented to reduce the likelihood of PTS. Such mitigation will include deployment of an ADD as recommended in the guidelines (JNCC, 2010c). The efficacy of ADDs as a mitigation tool was subsequently undertaken as part of this assessment with respect to both $SPL_{pk}$ and $SEL_{cum}$ ranges applying a 30-minute deployment time prior to hammer initiation. The exact duration of ADD activation will, however, be discussed and agreed with consultees post-consent and in respect of any refinements in the Project Description that may be available at a later stage and included within the outline MMMP (volume 4, appendix 22 of the Array EIA Report).

503. Based on the underwater noise modelling, ranges at which marine mammals could experience potential injury extend to up to 1,600 m ($SPL_{pk}$ metric for harbour porpoise). As such, tertiary mitigation will be required in the form of an ADD to deter animals from the area of impact. The type of ADD and approach to mitigation (including activation time and procedure) is included in the outline MMMP and will be further discussed and agreed with relevant stakeholders post-consent.

504. ADDs have commonly been used in marine mammal mitigation at UK offshore wind farms to deter animals from potential injury zones prior to the start of piling. The JNCC (2010c) draft guidance for piling mitigation recommends their use, particularly in respect of periods of low visibility or at night to allow 24-hour working. It is considered to be more effective at reducing the potential for injury to marine mammals compared to actions informed by standard monitoring measures (MMO[2] and PAM) which have limitations with respect to effective detection over distance (Parsons *et al.*, 2009, Wright *et al.*, 2015).

505. There are various ADDs available with different noise source characteristics (McGarry *et al.*, 2022) and a suitable device will be selected based on the key species requiring mitigation for the Array. The selected device will typically be deployed from the piling vessel and activated for a pre-determined duration to allow animals sufficient time to move away from the noise source whilst also minimising the additional noise introduced into the marine environment.

506. Therefore, underwater noise modelling was carried out to determine the efficacy of using ADDs for a duration of 30 minutes to reduce the risk of injury (see volume 3, appendix 10.1 of the Array EIA Report).

507. The maximum injury ranges using $SPL_{pk}$ metric were predicted for single pile installation at OSPs with a hammer energy of 4,400 kJ (Table 6.9). Assuming conservative swim speeds listed in Table 6.11, it was demonstrated that activation of an ADD for 30 minutes would deter all animals beyond the maximum injury zones.

**Table 6.11: Summary of Maximum PTS Ranges due to Single Pile Installation (at OSPs, Hammer Energy 4,400 kJ) Using $SPL_{pk}$ Metric, Indicating Whether the Individual Can Move Beyond the Injury Range During the 30 minutes of ADD Activation**

| Species (Hearing Group) | Metric | Threshold | PTS range (m) | Swim speed (m/s) | Swim distance (m) | Move Away Beyond the Maximum Injury Zone? |
|---|---|---|---|---|---|---|
| Harbour porpoise (VHF) | $SPL_{pk}$ | 202 dB re 1 µPa (pk) | 1,600 | 1.5 | 2,700 | Yes |
| Bottlenose dolphin (HF) | $SPL_{pk}$ | 230 dB re 1 µPa | 171 | 1.52 | 2,736 | Yes |
| Grey seal (PCW) | $SPL_{pk}$ | 218 dB re 1 µPa | 379 | 1.8 | 3,240 | Yes |

508. The maximum injury ranges using $SEL_{cum}$ metric were predicted for concurrent pile installation at wind turbine and OSP with hammer energies of 3,000 kJ and 4,400 kJ respectively (Table 6.10). Activation of an ADD 30 minutes prior to commencement of piling reduced injury ranges to a level which does not exceed injury thresholds for all species (Table 6.12).

**Table 6.12: Summary of Maximum PTS Ranges due to Concurrent Pile Installation (at Wind Turbine and OSP, Hammer Energies of 3,000 kJ and 4,400 kJ) Using $SEL_{cum}$ Metric With and Without 30 Minutes of ADD Activation (N/E = Threshold Note Exceeded)**

| Species (Hearing Group) | Metric | Threshold | Potential Injury Ranges (m) | |
|---|---|---|---|---|
| | | | Without ADD | With 30 Min ADD |
| Harbour porpoise (VHF) | $SEL_{cum}$ | 155 dB re 1 µPa$^2$s | 203 | N/E |
| Bottlenose dolphin (HF) | $SEL_{cum}$ | 185 dB re 1 µPa$^2$s | N/E | N/E |
| Grey seal (PCW) | $SEL_{cum}$ | 185 dB re 1 µPa$^2$s | N/E | N/E |

Behavioural disturbance

509. Disturbance during piling was predicted to have far-reaching potential effects across the northern North Sea. It should be noted that the extent of the contours is likely to be an overestimate as it assumes that the noise from piling maintains its impulsive characteristics at large distances, which is considered unlikely to be the case. Since there is no agreed approach to modelling the cross-over point from impulsive to continuous noise and this is an ongoing active area of research (see volume 3, appendix 10.1 for more details), it was not possible to account for it in the underwater noise modelling. Applying associated impulsive noise thresholds for the whole contour range is likely to overestimate predicted impact distances and therefore leads to a potentially over-precautionary assessment. Considering the above as well as caveats highlighted by Southall *et al.* (2021) (see paragraph 454 *et seq.* for more details), quantitative assessment of disturbance based on $SEL_{ss}$ metric should be interpreted with caution.

510. The estimated numbers of animals predicted to experience potential disturbance as a result of different piling scenarios are presented in Table 6.13. It should be noted that these are derived from information presented in the assessment of significance in the Array EIA Report, which are derived from relevant dose-

responses for each species, rather than an area-based assessment. The estimated numbers of animals potentially disturbed are based on the MDS which describes the maximum potential effect for each species. This has been defined with reference to either the extent of the effect, or spatial overlap with abundance hotspots (e.g. areas near the coast).

511. For grey seal the quantitative assessment (which used the dose-response) was undertaken by overlaying the unweighted $SEL_{ss}$ contours for the piling location that would result in the highest overlap with the density hotspots based on at-sea density maps produced by Carter *et al.* (2022) (Table 6.3). The number of animals in each 5 km x 5 km grid cell was summed for each isopleth and corrected using the proportional dose response as per Whyte *et al.* (2020).

512. For harbour porpoise, a quantitative assessment of the number of animals predicted to experience disturbance was undertaken by multiplying the density values (Table 6.3) with the areas within each 5 dB isopleth for the piling location that would result in the highest number of animals potentially disturbed and correcting the value using the relevant proportional dose response from Graham *et al.* (2019).

513. For the bottlenose dolphin Coastal East Scotland MU population, given its coastal distribution, a piling location taken forward to the assessment was chosen based on the highest overlap of noise disturbance contours with the MU boundaries. The calculations of the number of animals predicted to experience disturbance (which used the dose-response) were undertaken by multiplying the density values from Lacey *et al.* (2022) (Table 6.3) with the areas within each 5 dB isopleth that overlap with the MU boundaries and correcting the value using the relevant proportional response from Graham *et al.* (2019) for the unweighted $SEL_{ss}$ level.

514. To facilitate an area-based assessment for HRA purposes for harbour porpoise, the unweighted noise threshold value of 143 dB re $1\mu Pa^2 s$ $SEL_{ss}$ have been presented (paragraph 448). This threshold is relevant to the HRA process as it is an area-based approach and is therefore similar to the JNCC guidance on the use of EDRs to assess noise disturbance at harbour porpoise SACs (JNCC, 2020). Although the JNCC (2020) guidance applies to England, Wales, and Northern Ireland, it is still relevant to this assessment as the Southern North Sea SAC lies within English waters. An EDR of 26 km has also been considered in the assessment on the harbour porpoise feature of the Southern North Sea SAC as per the recommendation presented in JNCC (2020).

515. For bottlenose dolphin and grey seal, the NMFS (2005) unweighted thresholds of 160 dB re 1 μPa (rms) (strong disturbance) and 140 dB re 1 μPa (rms) (mild disturbance) have also been presented and discussed for their respective SACs (as described in paragraphs 446 to 453).

516. For all species, figures showing the modelled $SEL_{ss}$ and $SPL_{rms}$ noise disturbance contours (and EDR for harbour porpoise) and a discussion of the modelling are provided below for their relevant SACs.

**Table 6.13: Potential Number of Annex II Marine Mammals Predicted to be Disturbed Within Weighted $SEL_{ss}$ Noise Contours Based On Relevant Dose-Responses (Graham *et al.*, 2019, Whyte *et al.*, 2020) as a Result of Different Piling Scenarios. The Bold Numbers Represent Scenarios for Modelling Location With the Highest Number of Animals Potentially Impacted**

| Species (Hearing Group) | Reference Population | Piling Scenario | Maximum Hammer Energy (kJ) | Number of Animals | % of Reference Population |
|---|---|---|---|---|---|
| Harbour porpoise (VHF) | North Sea MU | Single | 3,000 kJ | 3,856 | 1.11 |
| | | Single | 4,400 kJ | 7,309 | 2.11 |
| | | Concurrent | 3,000 kJ + 3,000 kJ | 5,950 | 1.72 |
| | | Concurrent | 3,000 kJ + 4,400 kJ | **8,309** | **2.4** |
| Bottlenose dolphin (HF) | Coastal East Scotland MU | Single | 3,000 kJ | 2 | 0.89 |
| | | Single | 4,400 kJ | 4 | 1.79 |
| | | Concurrent | 3,000 kJ + 3,000 kJ | 3 | 1.34 |
| | | Concurrent | 3,000 kJ + 4,400 kJ | **5** | **2.23** |
| Grey seal (PCW) | East Scotland SMU and Northeast England SMU | Single | 3,000 kJ | 131 | 0.36 |
| | | Single | 4,400 kJ | 343 | 0.94 |
| | | Concurrent | 3,000 kJ + 3,000 kJ | 231 | 0.63 |
| | | Concurrent | 3,000 kJ + 4,400 kJ | **436** | **1.19** |

Summary of iPCoD modelling

517. To aid with the assessment of magnitude, the potential for population-level consequences of behavioural disturbance has been considered using the iPCoD approach for harbour porpoise, bottlenose dolphin, and grey seal. There is limited understanding of how behavioural disturbance and auditory injury affect survival and reproduction in individual marine mammals and consequently how this translates into potential effects at the population-level. The iPCoD framework was developed using a process of expert elicitation to determine how physiological and behavioural changes affect individual vital rates (i.e. the components of individual fitness that affect the probability of survival, production of offspring, growth rate and offspring survival). The iPCoD framework applies simulated changes in vital rates to infer the number of animals that may be affected by disturbance as a means to iteratively project the size of the population.

518. For bottlenose dolphin, the Coastal East Scotland MU was used as the relevant reference population. Given the importance of the Moray Firth SAC for bottlenose dolphin in this area, the sensitivity of this population and its known ranging behaviour further south towards St Andrews Bay and the Tay Estuary, and inshore in north-east English waters, it is important to capture the potential impact on this important coastal ecotype which may experience potential barrier effects.

519. Whilst there is an abundance estimate for the Greater North Sea MU (2,022 animals (IAMMWG, 2023)) this large MU extends the entire length of the east coast of the UK and east to Scandinavia, so apportioning numbers of the offshore ecotype to the east coast of Scotland is not possible. It is also unlikely that the Array will create significant barrier effects for this offshore ecotype. Therefore, the assessment has focused on the impacts for bottlenose dolphin within the Coastal East Scotland MU and Moray Firth SAC.

520. For harbour porpoise, only the North Sea MU for occurs in the vicinity of the Array marine mammal study area (IAMMWG, 2023), and the population estimates for it have been used for iPCoD modelling. The site boundary coincides with the boundary between two SMUs, so for grey seal the reference population comprises the sum of the East Scotland SMU and the Northeast England SMU (SCOS, 2023) (see section 6.2.4).

521. The population estimates used to parameterised iPCoD models were taken from IAMMWG (2023) for cetacean species and from SCOS (2023) and Stevens (2023) and for grey seal, (summarised in Table 6.3), alongside vital rates taken from Sinclair *et al.* (2020), presented in Table 6.14.

**Table 6.14: Vital Rates Used to Parameterise iPCoD Models (from Sinclair *et al.* (2020))**

| Species | Calf/Pup Survival | Juvenile Survival | Adult Survival | Fertility | Age of Independence | Age of First Birth |
|---|---|---|---|---|---|---|
| Harbour porpoise | 0.8455 | 0.85 | 0.925 | 0.34 | 1 | 5 |
| Bottlenose dolphin | 0.9250 | 1.00 | 1.000 | 0.24 | 3 | 9 |
| Grey seal | 0.2220 | 0.94 | 0.940 | 0.84 | 1 | 6 |

522. The dual metric approach has been used to inform the PTS assessment, but $SPL_{pk}$ used to define the appropriate mitigation range following advice from NatureScot (received as a result of Marine Mammal Consultation Note 1; Table 2.1). The number of animals that may experience PTS to be inputted into the iPCoD models were derived from calculations based upon the most animals effected from the dual metric approach (paragraph 445) using numbers of animals from dose-response approach. Furthermore, calculation of the number of animals that may experience PTS assumed a 30-minute implementation of ADD, as per standard industry practice and was agreed with NatureScot (following Marine Mammal Consultation Note 1).

523. Both the maximum temporal scenario (e.g. the single piling scenario with fewer animals impacted per day, but over more days) and the maximum spatial scenario (e.g. the concurrent piling scenario with more animals impacted per day, but for fewer days) were modelled in iPCoD. It should be noted that for the RIAA, that the populations of the MUs and SMUs used in the iPCoD modelling cannot be directly attributed or allocated to the specific populations within the SACs being assessed. However, the results of the iPCoD modelling still provide important context at a population level which aids the overall assessment.

524. Results of population modelling are discussed for each SAC below, with further detail provided in volume 2, chapter 10 of the Array EIA Report.

## Construction phase

Berwickshire and North Northumberland Coast SAC

**Grey seal**

*Injury*

525. Based on $SPL_{pk}$ metric, the maximum range for injury to grey seal was estimated as 379 m during pile installation at OSPs (Table 6.9). Applying a density value of 0.180 animals per km$^2$, no more than one animal would be at risk of experiencing PTS (based on the dose response approach). However, with designed-in measures applied, it is predicted that no animals would be affected by peak pressure ($SPL_{pk}$) as they would be able to flee the potential injury range (379 m) during the period of ADD activation (Table 6.11).

526. Given that the injury range is within hundreds of metres, it will be localised to within the Array marine mammal study area and therefore there is no potential for spatial overlap with the Berwickshire and North Northumberland Coast SAC (which is a minimum of 113.95 km away).

527. Grey seal typically live between 20 to 30 years with gestation lasting between ten to 11 months (SCOS, 2023). The duration of piling is up to 602 days, within an eight-year piling programme, and therefore could potentially overlap with a maximum of eight breeding cycles. It should be noted that piling at OSPs with the hammer energy of 4,400 kJ resulting in maximum injury range of 379 m would take place over only a fraction of the total piling days (72 days). The total duration of the impact in the context of the life cycle of grey seal is classified as medium term, as animals will be at the risk of potential injury (albeit very small) over a meaningful proportion of their lifespan.

528. As stated in paragraph 523, whilst the populations of the SMUs cannot be directly attributed or allocated to the specific population within the Berwickshire and North Northumberland Coast SAC, the results of the iPCoD modelling still provide important context at a population level to help inform the overall assessment.

529. Simulated trajectories for both the unimpacted and the impacted grey seal populations (using the total population estimate for the East Scotland SMU (10,783) and Northeast England SMU (25,913)) were modelled using iPCoD for the maximum temporal and spatial scenario. The results of the iPCoD modelling for grey seal against these SMU populations showed that the median ratio of the impacted population to the unimpacted population was 1.000 at six years and 25 years, for both the maximum temporal scenario and the maximum spatial scenario. This indicates that there would be no significant difference between the population trajectories for the unimpacted (baseline) population and the impacted population. At 25 years after the start of piling there was no difference in the number of animals in the impacted population when compared to the unimpacted population, for both the maximum temporal and maximum spatial scenario. It is therefore considered that there would be no potential long-term effects on the grey seal population of these SMUs resulting from elevated underwater noise arising during piling.

*Behavioural disturbance*

530. There was no overlap of the unweighted $SEL_{ss}$ 145 dB re 1 μ$Pa^2$s contour for grey seal (Whyte *et al.*, 2020) with the Berwickshire and North Northumberland Coast SAC (Figure 6.3 and Figure 6.4). The Array EIA Report (which used dose response) found that up to 436 animals were predicted to potentially be disturbed within weighted $SEL_{ss}$ noise disturbance contours, which equates 1.19% of the total East Scotland SMU and Northeast England SMU population (Table 6.13). However, it is important to note that for the Appropriate Assessment, numbers of animals potentially disturbed cannot be accurately attributed or apportioned to an individual SAC using an area based approach (such as the NMFS (2005) thresholds of 160 and 140 dB (rms) for strong and mild disturbance). An area-based approach assumes 100% disturbance of all animals within the area rather than a continuum, and therefore would lead to a vast over-estimate of numbers of animals if simply multiplied by a conservative density value. Furthermore, loss of habitat area (as is the case for area-based assessment) is a binary event, with an area is either ensonified by a sound at a given level or not (NRW, 2023).

531. There was no overlap of the 160 dB (rms) or 140 dB (rms) contours for strong and mild disturbance, respectively, (based on NMFS (2005)) with the Berwickshire and North Northumberland Coast SAC (Figure 6.5 and Figure 6.6). The areas of the strong disturbance contours were 1,698.50 $km^2$ at the northern piling scenario and 1,515.87 $km^2$ at the southern piling scenario. The areas of the mild disturbance contours were 45,638.41 $km^2$ at the northern piling scenario and 45,888.84 $km^2$ at the southern piling scenario. However, no estimates of the number of grey seal with the potential to be disturbed within these areas has been provided, given the inaccuracies associated with doing so using an area-based approach in contrast to a dose-response (see paragraphs 446 *et seq.*). It is acknowledged that grey seal foraging trips can be wide ranging (i.e. <100 km; (SCOS, 2022)), however during the breeding season, they are typically within 20 km of the haul out sites (*pers. comm.,* with NatureScot). Therefore, no overlap with any of the contours presented in Figure 6.3 to Figure 6.6 is likely to occur during this key stage of the species' life history.

*Conclusion*

532. Adverse effects on the qualifying Annex II grey seal feature of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise generated during piling in the construction phase for the Array alone. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.1) are discussed in turn below in Table 6.15.

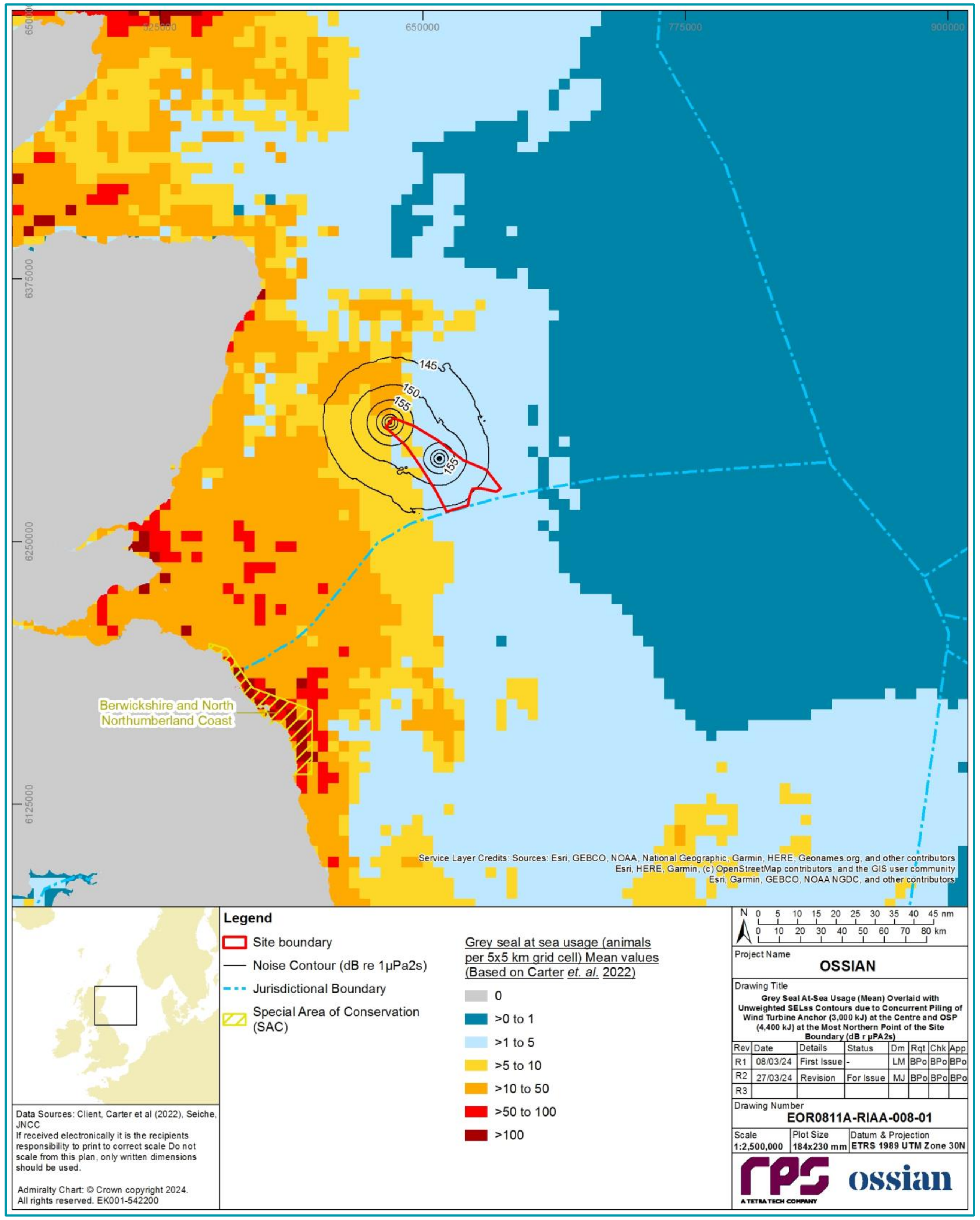


**Figure 6.3: Unweighted $SEL_{ss}$ Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary overlaid with Carter *et al.* (2022) At-sea Density Maps and Berwickshire and North Northumberland Coast SAC**

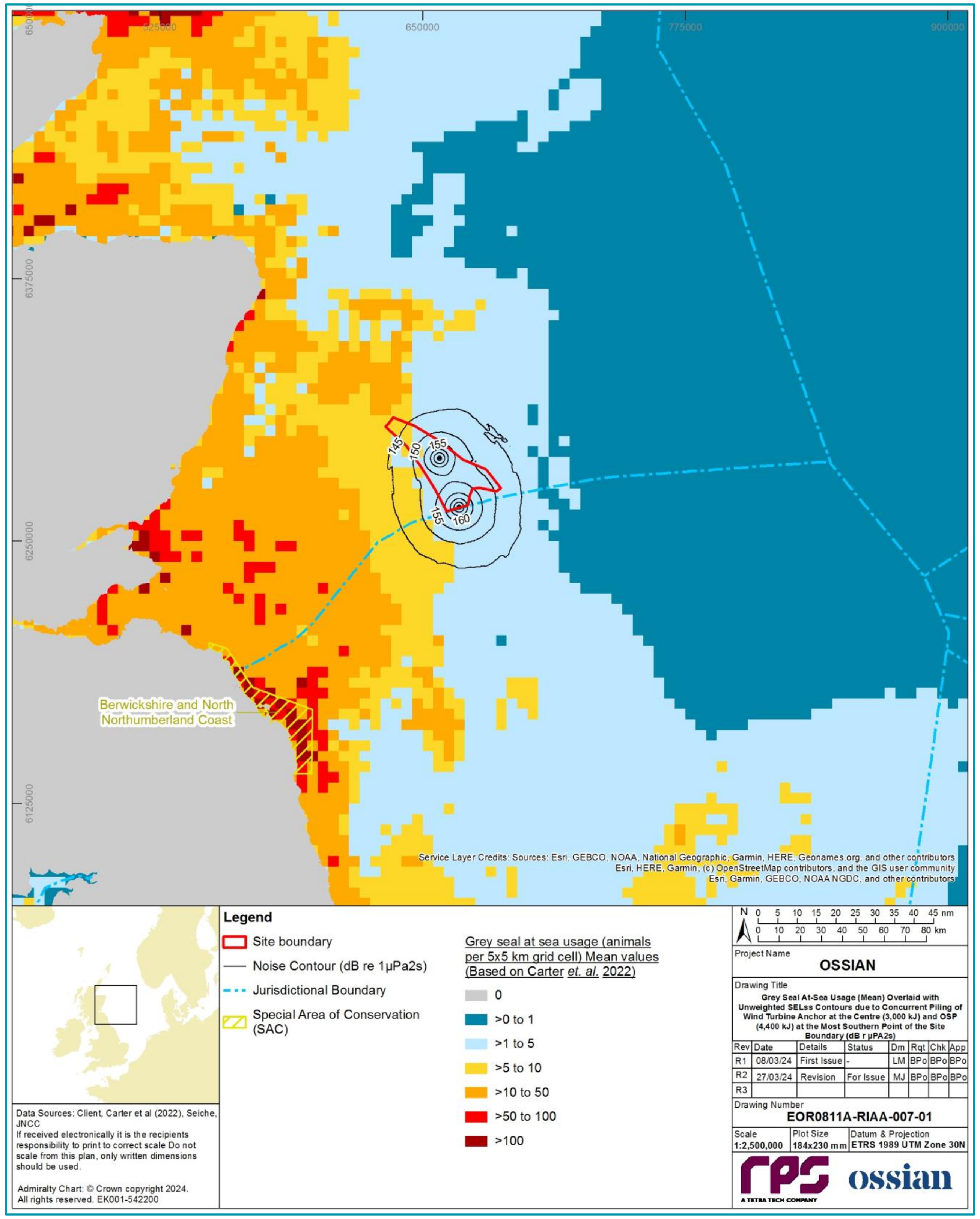


**Figure 6.4:** Unweighted SELss Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Southern Limit of the Site Boundary overlaid with Carter *et al.* (2022) At-sea Density Maps and Berwickshire and North Northumberland SAC

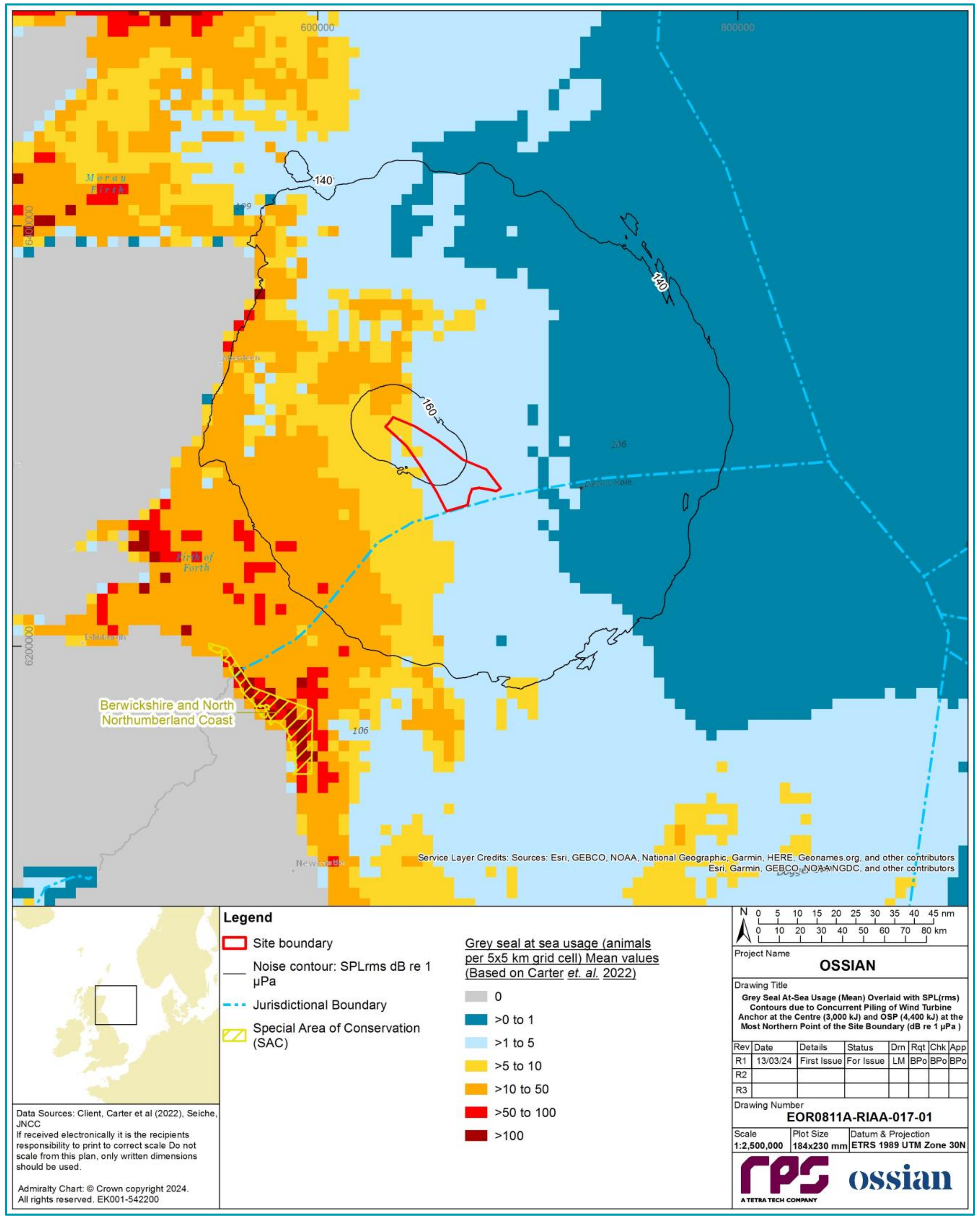


**Figure 6.5:** Unweighted 140 and 160 dB re 1 µPa ($SPL_{rms}$) Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary overlaid with Carter *et al.* (2022) At-sea Density Maps

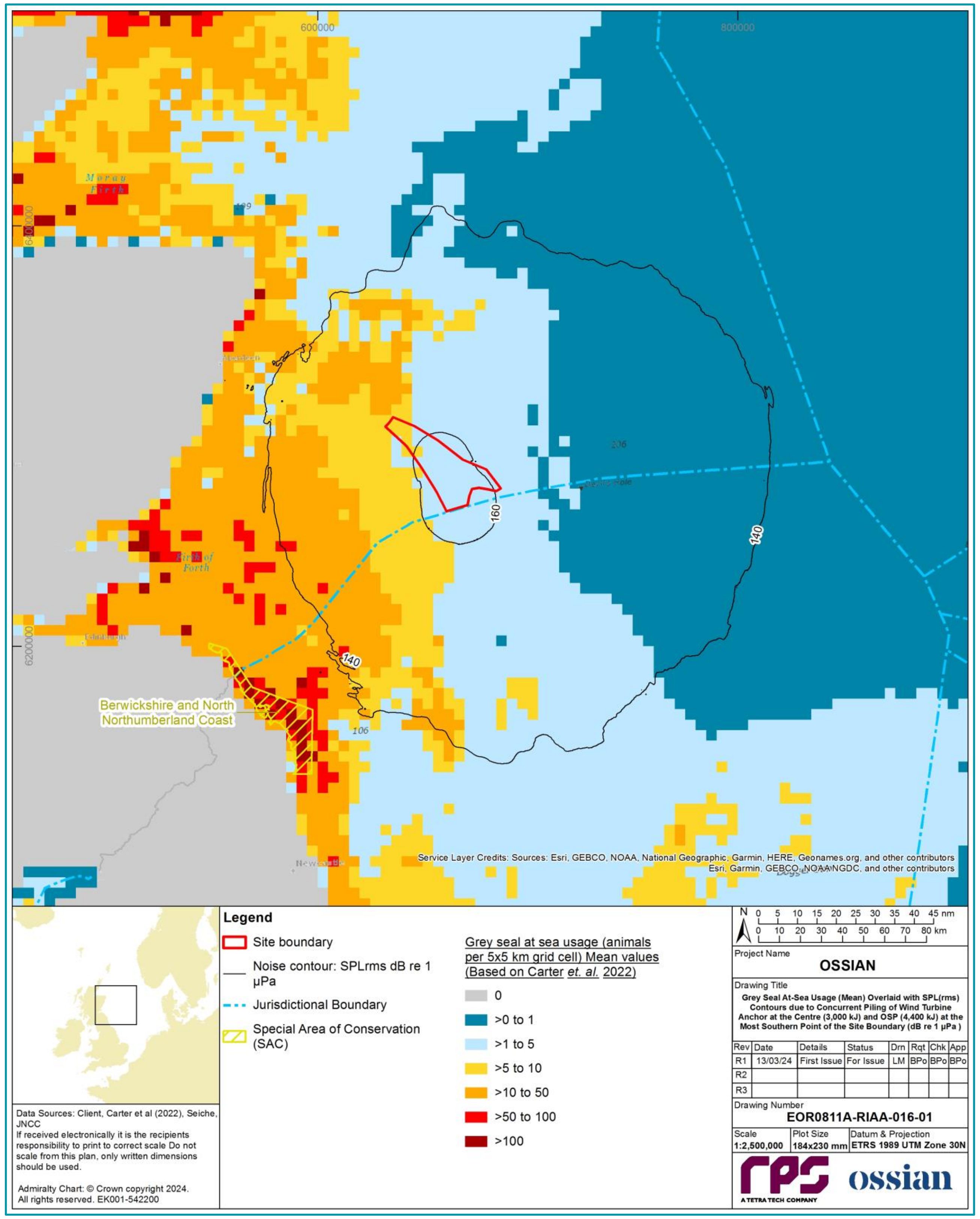


**Figure 6.6: Unweighted 140 and 160 dB re 1 µPa ($SPL_{rms}$) Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Southern Limit of the Site Boundary overlaid with Carter *et al.* (2022) At-sea Density Maps**

**Table 6.15: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Underwater Noise Generated During Piling in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for impact between underwater noise generated during piling and the extent, distribution, structure, and function of the habitats and supporting processes of grey seal (i.e. no overlap with the area of significant disturbance with the SAC). Therefore, the presence, abundance, condition and diversity of habitats and species required to support grey seal will not be adversely affected by this impact. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | Overall, piling during the construction phase is unlikely to lead to injury, barrier effects, or strong behavioural responses. The assessment has concluded that piling is highly unlikely to disrupt the population or distribution of grey seal associated with this SAC. In terms of injury due to piling, it was predicted that the designed in measure of ADD activation would result in no animals being affected by peak pressure ($SPL_{pk}$) as they would be able to flee the potential maximum injury range of 379 m. Therefore, the populations and distribution of grey seal are not likely to be impacted by injury associated with piling.<br><br>The total duration of the piling in the context of the life cycle of grey seal was classified as medium term, as animals will be at the risk of potential injury (albeit very small) over a meaningful proportion of their lifespan (see paragraph 527). However, simulated trajectories for both the unimpacted and the impacted grey seal populations (using the total population estimate for the East Scotland SMU (10,783 animals) and Northeast England SMU (25,913 animals)) were modelled using iPCoD for the maximum temporal and spatial scenario. The modelling indicated that there would be no significant difference between the population trajectories for the unimpacted (baseline) population and the impacted population. It was therefore considered that there would be no potential long-term effects on the population or distribution of grey seal.<br><br>There was no overlap of the 160 dB rms (strong disturbance) or 140 dB (rms) (mild disturbance) contours (based on NMFS (2005)) for grey seal with the SAC. The Array EIA Report (which used the dose-response) presented the most conservative estimate of up to 436 animals predicted to be disturbed within unweighted $SEL_{ss}$ noise disturbance contours, which equates 1.19% of the total East Scotland SMU and Northeast England SMU population. Given that grey seals are likely to return to the same area on subsequent trips following cessation of piling, it will not result in any long-term changes in the distribution of seals from this SAC and the connectivity with areas of high importance within and outside the site is not expected to be impaired (such as foraging grounds). |
| | The distribution of qualifying species within the site are maintained | |

533. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of underwater noise generated during piling in the construction phase of the Array alone.

Southern North Sea SAC

**Harbour porpoise**

*Injury*

534. Based on $SPL_{pk}$ metric, the maximum range for injury to harbour porpoise was estimated as 1,600 m during pile installation at OSPs (Table 6.9). Based on the density value of 0.651 animals per $km^2$, up to six animals would be at risk of experiencing PTS. However, with designed-in measures applied, it is predicted that no animals would be affected by peak pressure ($SPL_{pk}$) as they would be able to flee the potential injury range (1,600 m) during the period of ADD activation (Table 6.11).

535. The injury range is predicted to be localised to within the Array marine mammal study area and therefore there is no potential for spatial overlap with the Southern North Sea SAC (which is a minimum of 129.86 km away).

536. Harbour porpoise typically live between 12 and 24 years and give birth once a year (Lockyer, 2013). The duration of piling is up to 602 days, within an eight-year piling programme, and therefore could potentially overlap with a maximum of eight breeding cycles. It should be noted that piling at OSPs with the hammer energy of 4,400 kJ resulting in maximum injury range of 1,600 m would take place over only a fraction of the total piling days (72 days). The total duration of the impact in the context of the life cycle of harbour porpoise is classified as long term, as animals will be at the risk of potential injury (albeit very small) over a meaningful proportion of their lifespan.

537. Simulated trajectories for both the unimpacted and the impacted harbour porpoise populations (using the total population estimate for the North Sea MU) were modelled using iPCoD for the maximum temporal and spatial scenario. The results of the iPCoD modelling of the maximum temporal scenario for harbour porpoise showed that the median ratio of the impacted population to the unimpacted population at six years was 0.9986 and at 25 years was 0.9985. For the maximum spatial scenario these ratios were 0.9995 at six years and 0.9994 at 25 years. For both scenarios, results indicated no significant difference between the population trajectories for an unimpacted population and the impacted population. 25 years after the start of piling, the simulated impacted population was estimated to be 1,878 animals smaller than the unimpacted population for the maximum temporal scenario, equating to 0.005% of the North Sea MU population. For the maximum spatial scenario, there were estimated to be 1,302 fewer animals in the impacted versus unimpacted population, equating to 0.004% of the MU population. Given these results, it is expected that there would be no potential long-term effects on the harbour porpoise population of the North Sea MU resulting from elevated underwater noise arising during piling. As stated in paragraph 523, the population of the North Sea MU cannot be accurately attributed or allocated to the specific population within the Southern North Sea SAC. However, the results of the iPCoD modelling still provide relevant context at a population level to inform the overall assessment.

*Behavioural disturbance*

538. The Array EIA Report (which used dose response) found that at the most conservative scenario for concurrent piling of the wind turbine (3,000 kJ) in the centre and OSPs (4,400 kJ) at the Northern limit of the site boundary, up to 8,309 harbour porpoise could experience potential disturbance (Table 6.13; Figure 6.7). This equates to 2.4% of the North Sea MU population (Table 6.13). The estimated number of individuals potentially impacted was based on conservative densities and the assumption that the peak seasonal site-specific density of 0.651 animals per $km^2$ is uniformly distributed within all noise contours. Additionally, the underwater noise modelling assumed that the maximum hammer energies are reached at all piling locations (see volume 3, appendix 10.1 of the Array EIA Report for more details), which is highly conservative.

539. Given the far-reaching extent of the outer noise contours, there is potential for overlap with the Southern North Sea SAC. Based on the dose-response curve presented in Graham *et al.* (2019), from 1% to 4% of animals are likely to respond within noise contours that overlap with this SAC (120 to 130 dB $SEL_{ss}$) which is also below the NMFS (2005) threshold for strong disturbance (=160 dB rms). Moreover, there is a possibility that a small number of individuals from this SAC population may be occasionally present within the mapped disturbance contours outside the site. Therefore, using the area-based approach (as described in paragraphs 446 to 453) for the unweighted noise threshold of 143 dB re 1µ$Pa^2$s disturbance contours were presented for the maximum design scenario concurrent piling at wind turbines (3,000 kJ) in the centre and OSPs (4,400 kJ) at the southern limit of the site boundary (i.e. the closest to the SAC) (Figure 6.8). This approach, which focuses on a threshold associated with the onset of avoidance behaviour, showed that the 143 dB re 1µ$Pa^2$s disturbance contour does not extend to the Southern North Sea SAC and therefore animals are unlikely to experience significant disturbance within the site. Additionally, at these distances it is unlikely that noise contours would result in barrier effects restricting harbour porpoise from reaching key habitats within the SAC.

540. The different approaches described above suggest that close to the piling the disturbance response is likely to be measurable and the probability of such a response is high such that individuals could change their baseline behaviour or in some cases actively avoid disturbed areas. Moving further away from the piling source, behavioural responses are likely to decrease with some individuals (proportional to the distance from the source) tolerating the increase in elevated underwater noise. At ranges beyond the received level of 143 dB re 1 µ$Pa^2$s ($SEL_{ss}$) the disturbance is unlikely to be significant with less likelihood of active avoidance (Brandt *et al.*, 2018, NRW, 2023).

541. A 26 km EDR has also been presented on Figure 6.7 and Figure 6.8, as per the JNCC guidance to assess noise disturbance at harbour porpoise SACs (JNCC, 2020). This is relevant to the Array, as although it lies within Scottish waters, the Southern North Sea SAC lies within English waters. As illustrated, there is no potential for overlap between the 26 km EDR and the Southern North Sea SAC (Figure 6.7 and Figure 6.8).

*Conclusion*

542. Adverse effects on the qualifying Annex II harbour porpoise feature of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise generated during piling in the construction phase for the Array alone. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.16.

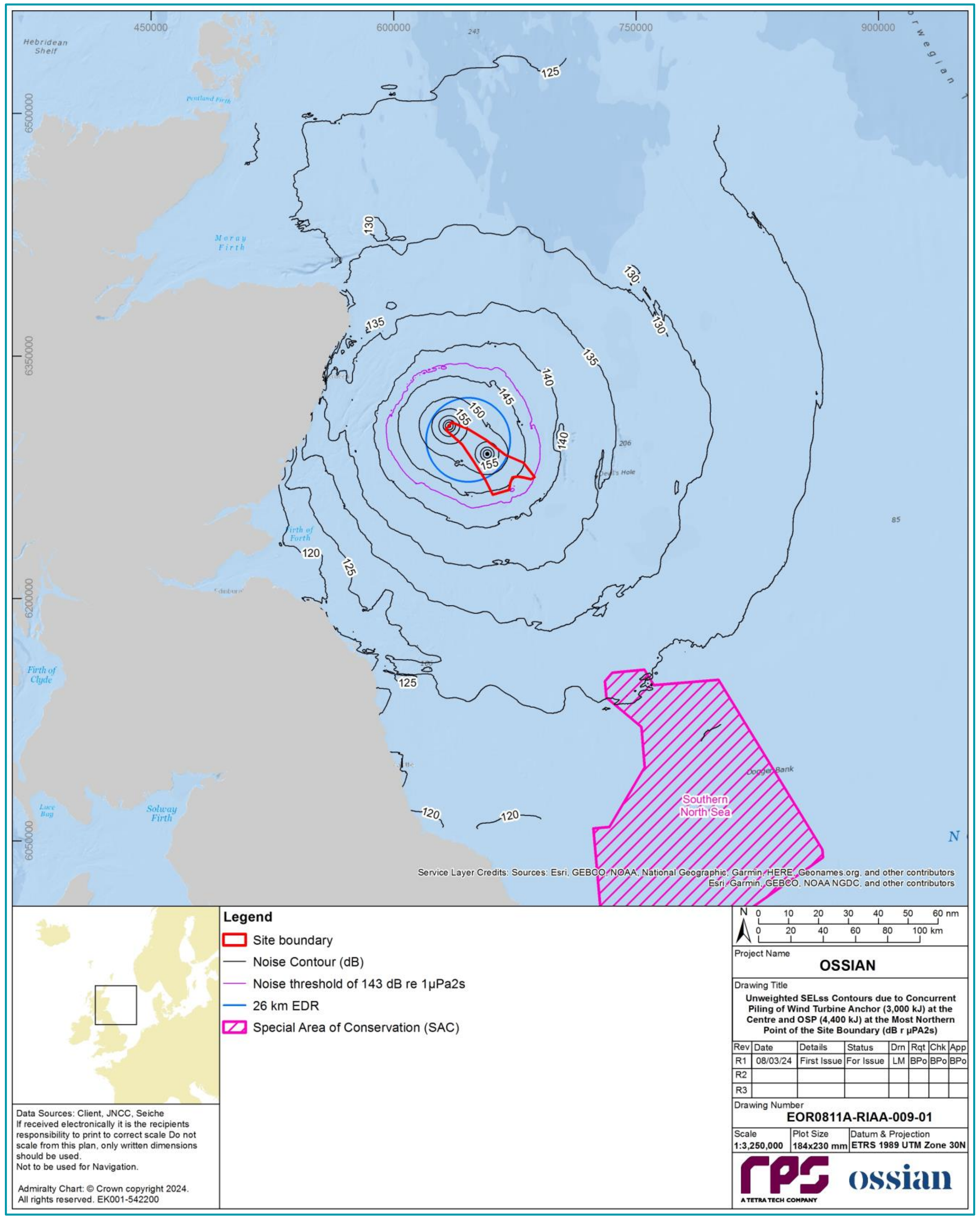


**Figure 6.7: Unweighted $SEL_{ss}$ Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary and 26 km EDR**

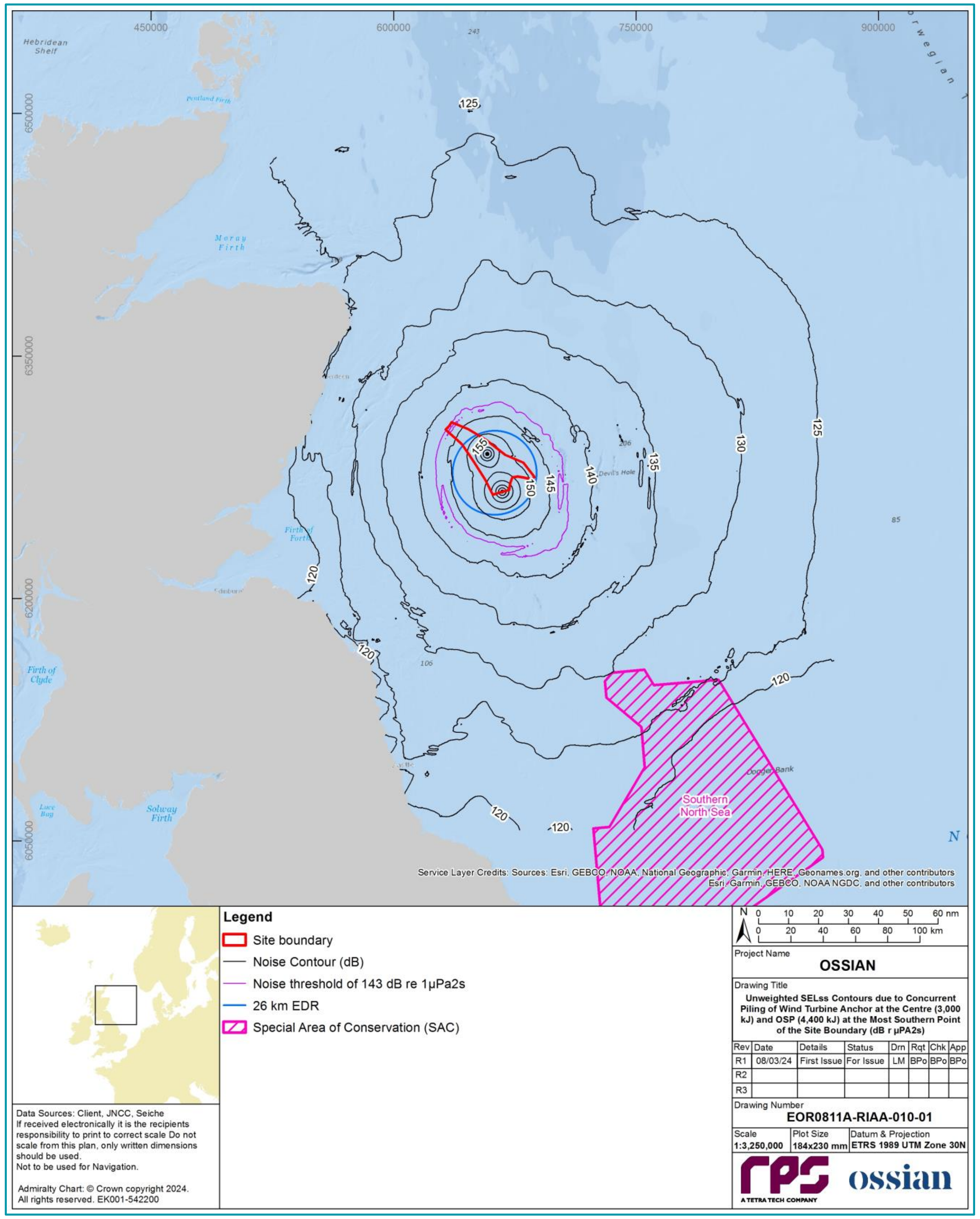


**Figure 6.8: Unweighted $SEL_{ss}$ Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Southern Limit of the Site Boundary and 26 km EDR**

Table 6.16: **Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Underwater Noise Generated During Piling in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1.Harbour porpoise is a viable component of the site | For harbour porpoise, as outlined in paragraph 534, with an ADD (of 30 minutes) applied, there is predicted to be no residual risk of injury during piling activities associated with the construction phase. In addition, the implementation of the MMMP as a designed in measure will further reduce the number of individuals injured further as they will be deterred beyond the predicted injury ranges.<br><br>The maximum area of disturbance based on the 26 km EDR from JNCC (2020) does not overlap the Southern North Sea SAC (Figure 6.7 and Figure 6.8). Further, the unweighted $SEL_{ss}$ 143 dB re 1μPa²s disturbance contour does not extend to the Southern North Sea SAC and therefore animals are unlikely to experience significant disturbance within the site (Figure 6.7 and Figure 6.8). Additionally, at these distances, it is unlikely that noise contours would result in barrier effects restricting harbour porpoise from reaching key habitats within the SAC. Piling will therefore not affect areas important for breeding and calving within the SAC, and therefore harbour porpoise will remain a viable component of the site. Overall, underwater noise generated during piling is not predicted to impact the population from being able to maintain itself as a viable component of its natural habitat over the long term (as per the iPCoD modelling results). |
| | 2. There is no significant disturbance of the species | As detailed in the row above, the maximum areas of disturbance based on the 26 km EDR, the unweighted $SEL_{ss}$ 143 dB re 1μPa²s, and $SPL_{rms}$ strong and mild disturbance contours do not overlap with to the Southern North Sea SAC and therefore animals are unlikely to experience significant disturbance within the site (Figure 6.7 to Figure 6.9). The Array EIA Report (which used dose response) found that at the most conservative scenario for concurrent piling of the wind turbine (3,000 kJ) in the centre and OSPs (4,400 kJ) at the Northern limit of the site boundary, up to 2.4% of the North Sea MU harbour porpoise population could experience disturbance. Further, the results of the iPCoD modelling demonstrated that there would be no long term population effects. Underwater noise generated during piling is therefore not predicted to impact the objective of no significant disturbance of the species within the site. |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for impact between underwater noise generated during piling and the habitats and supporting processes of harbour porpoise. With respect to the availability of prey (fish and shellfish), long term effects from piling were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.3.4), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support harbour porpoise will not be adversely affected by this impact. |

543. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of underwater noise generated during piling in the construction phase of the Array alone.

Moray Firth SAC

**Bottlenose dolphin**

*Injury*

544. Based on $SPL_{pk}$ metric, the maximum range for injury to bottlenose dolphin was estimated as 171 m during pile installation at OSPs (Table 6.9). Based on the density values of 0.003 animals per km², no more than one animal would be at risk of experiencing PTS. However, with designed in measures applied, it is predicted that no animals would be affected by peak pressure ($SPL_{pk}$) as they would be able to flee the potential injury range (171 m) during the period of ADD activation (Table 6.11).

545. The injury range is predicted to be localised to within the Array marine mammal study area and therefore there is no potential for spatial overlap with the Moray Firth SAC, the closest site designated for bottlenose dolphin (which is a minimum of 175.86 km north).

546. Bottlenose dolphin typically live between 20 and 30 years. The gestation period is 12 months with calves suckling for 18 to 24 months with females reproducing every three to six years (Mitcheson, 2008). The duration of piling is up to 602 days, within an eight-year piling programme, and therefore could potentially overlap with a maximum of three bottlenose dolphin breeding cycles. It should be noted that piling at OSPs with the hammer energy of 4,400 kJ resulting in maximum injury range of 171 m would take place over only a fraction of the total piling days (72 days). The total duration of the potential impact in the context of the life cycle of bottlenose dolphin is classified as long term, as animals will be at the risk of potential injury (albeit very small) over a meaningful proportion of their lifespan.

547. As stated in paragraph 523, the population of the Coastal East Scotland MU cannot be directly attributed or allocated to the specific population within the Moray Firth SAC. However, the results of the iPCoD modelling still provide important context at a population level to help inform the overall assessment. Simulated trajectories for both the unimpacted and the impacted bottlenose dolphin populations (using the total population estimate for the Coastal East Scotland MU) were modelled using iPCoD (using numbers from dose response) for the maximum temporal and spatial scenario. The results of iPCoD modelling for the Coastal East Scotland MU bottlenose dolphin population indicated that the median ratio of the impacted population to the unimpacted population was 1.000 at six years and at 25 years, for both the maximum temporal scenario and the maximum spatial scenario. A ratio of 1 corresponds to no significant difference between the population trajectories for an unimpacted population and the impacted population. 25 years after the start of piling, for the maximum temporal scenario the impacted population was predicted to be seven animals smaller than the unimpacted population, equating to 0.031% of the Coastal East Scotland MU. For the maximum spatial scenario, the impacted population was predicted to be four animals smaller than the unimpacted population, equating to 0.018% of the Coastal East Scotland MU. It is therefore considered that there would be no potential long-term effects upon the coastal bottlenose dolphin population resulting from elevated underwater noise arising during piling.

*Behavioural disturbance*

548. The Array EIA Report (which used dose response) found that based on the most conservative scenario for concurrent piling of the wind turbine (3,000 kJ) in the centre and OSPs (4,400 kJ) at the northern limit of the site boundary, up to five bottlenose dolphin are predicted to experience potential behavioural disturbance (Table 6.13; Figure 6.9). This equates to 2.23% of the Coastal East Scotland MU population (Table 6.13).

549. An area-based approach of the 140 dB and 160 dB (rms) contours for mild and strong disturbance, respectively, (based on NMFS (2005)) is presented in Figure 6.10. There was no overlap with the Moray Firth SAC and the strong or mild disturbance contours (Figure 6.10). The area of the strong disturbance contour was 1,698.50 km² and 45,638.41 km² for the mild disturbance contour. However, no estimates of the number of bottlenose dolphin with the potential to be disturbed within these areas has been provided, given the inaccuracies and likely vast over-estimation associated with doing so using an area-based approach in contrast to a dose-response (see paragraphs 446 *et seq.*). The following paragraphs provide a qualitative assessment, taking into account the known behaviour, ecology, and distribution of this species in the region.

550. The assessment assumed precautionarily that bottlenose dolphins from the Coastal East Scotland MU can be present within the whole extent of the MU (Figure 6.9), although it should be noted that empirical evidence from studies on this population suggest that they are mostly encountered 2 to 5 km from the shore (Palmer *et al.*, 2019, Paxton *et al.*, 2016, Quick *et al.*, 2014, Thompson *et al.*, 2015b). Animals from this MU are unlikely to be present in the offshore areas that may be exposed to high levels of noise from

piling at the Array. However, bottlenose dolphins from the offshore populations may experience behavioural disturbance outside the Coastal East Scotland MU. Given that there is an estimate of 2,022 animals for the entire Greater North Sea MU, which extends across to Europe (IAMMWG, 2022) and no further information on offshore populations, the effect has not been quantified for behavioural disturbance during piling outside the Coastal East Scotland MU. Further, the Coastal East Scotland MU is most relevant for the assessment of the Moray Firth SAC.

551. The Coastal East Scotland MU lies approximately 56 km west from the site boundary and at this distance the received level from piling will have lost much of the impulsive characteristics (Figure 6.9 and Figure 6.10). The outermost $SEL_{ss}$ noise contours reach the coastal areas and therefore may overlap with the key inshore distribution of bottlenose dolphin in the MU (Figure 6.9), potentially resulting in barrier effects (e.g. restricting animals from moving along the coast). Received noise levels within the Coastal East Scotland MU are predicted to reach maximum $SPL_{rms}$ levels of 140 dB (Figure 6.10), which is below the NMFS (2005) threshold for strong disturbance (=160 dB rms) and therefore likely to elicit less severe disturbance reactions. However, the modelled noise contours that overlap with the Coastal East Scotland MU meet the threshold for mild disturbance (=140 dB rms) (Figure 6.10). According to the behavioural response severity matrix suggested by Southall *et al.* (2021) such low level disturbance (scoring between 0 to 3 on a 0 to 9 scale) could lead to mild disruptions of normal behaviours, but prolonged or sustained behavioural effects, including displacement are unlikely to occur.

552. There is no potential for overlap of the $SEL_{ss}$ or the $SPL_{rms}$ noise disturbance contours (mapped out to 120 dB) with the Moray Firth SAC (Figure 6.9 and Figure 6.10). However, as noted in paragraph 550, there is a possibility that a small number of individuals from this SAC population may be occasionally present within the mapped disturbance contours outside the site (though, as discussed in paragraph 530, it is not possible to apportion numbers of animals disturbed to the Moray Firth SAC).

*Conclusion*

553. Adverse effects on the qualifying Annex II bottlenose dolphin feature of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise generated during piling in the construction phase for the Array alone. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.17.

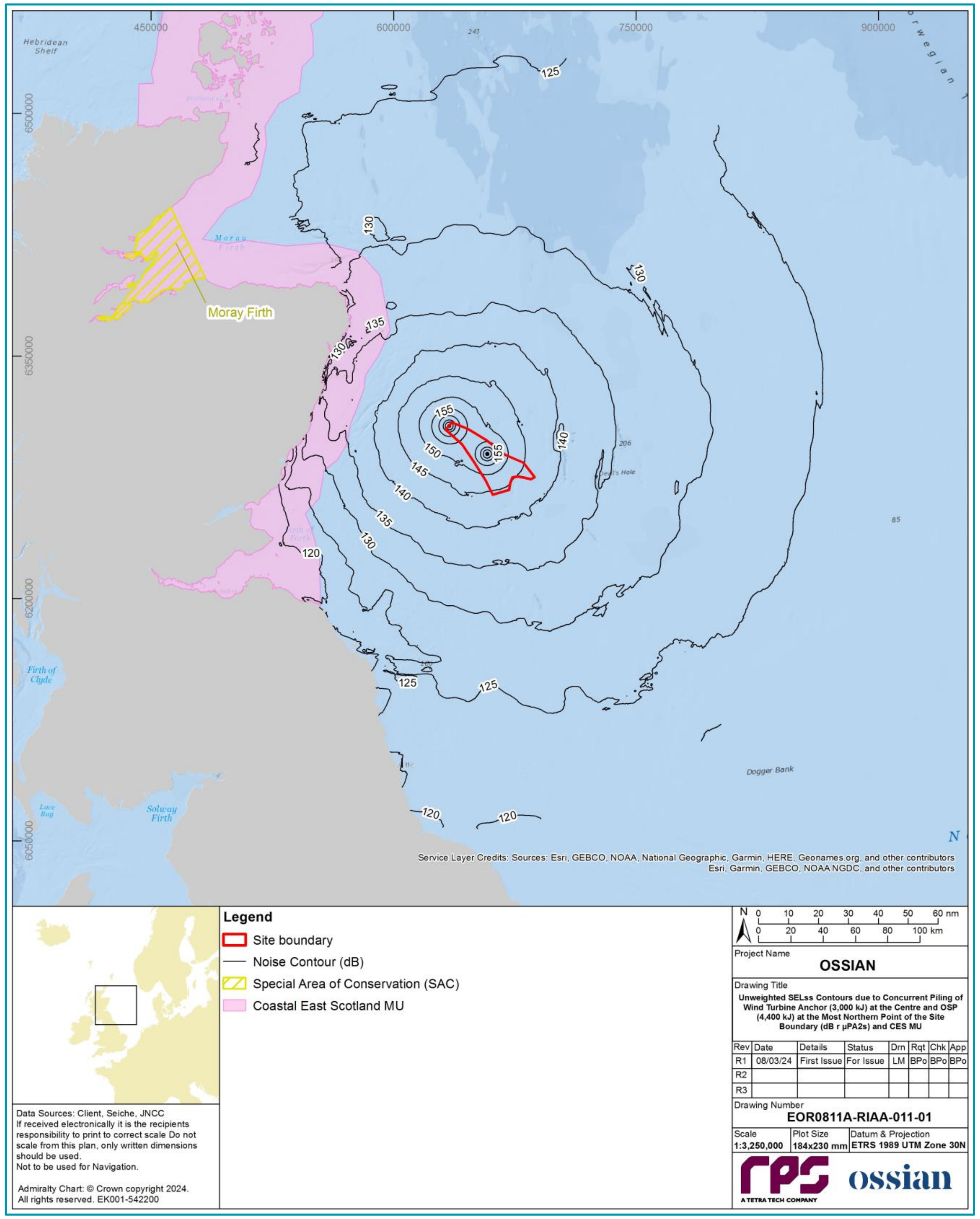


**Figure 6.9: Unweighted $SEL_{ss}$ Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary**

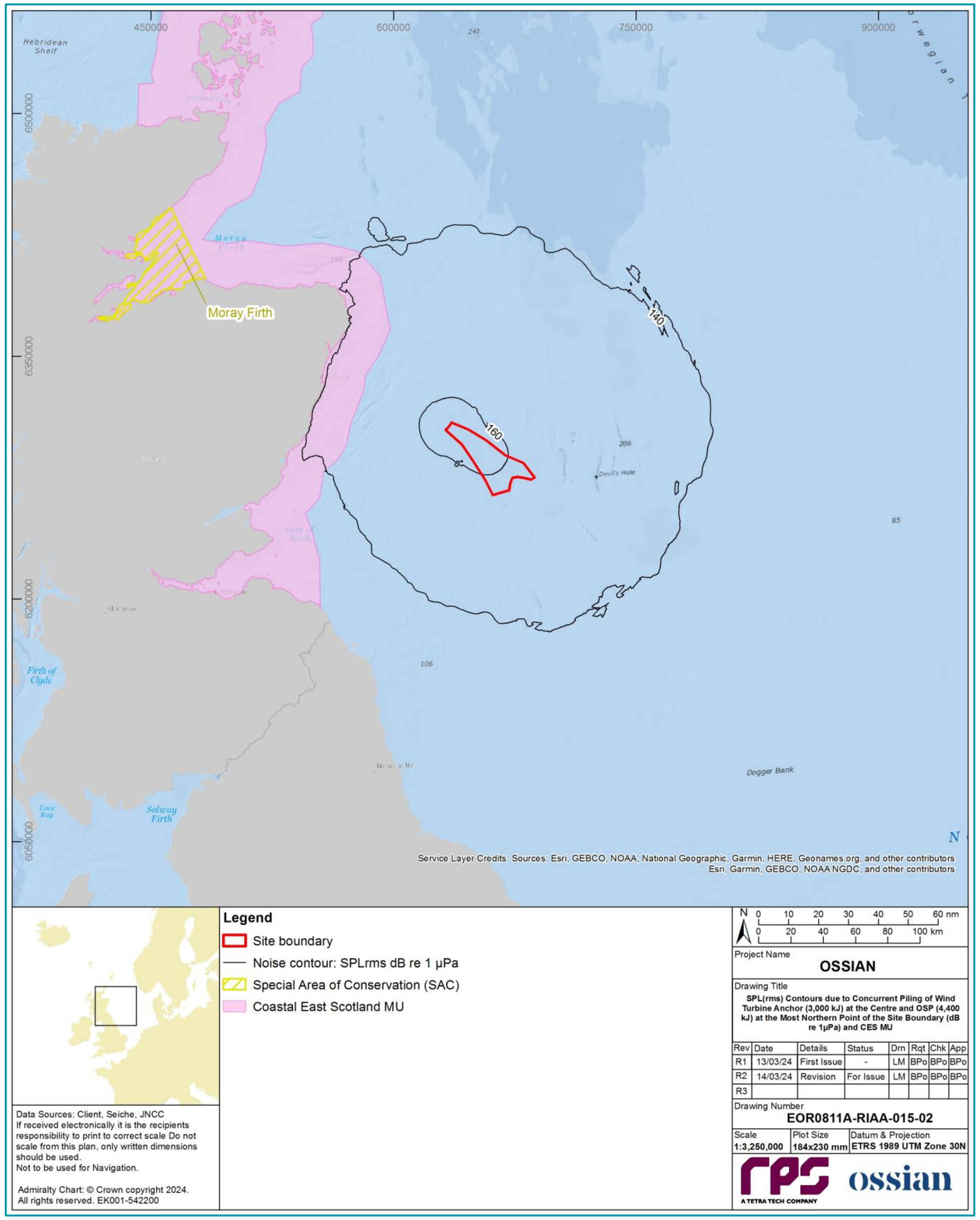


**Figure 6.10: Unweighted SPL$_{rms}$ Contours Due to Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary**

**Table 6.17: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Underwater Noise Generated During Piling in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site | For bottlenose dolphin, as outlined in paragraph 544, with an ADD (of 30 minutes) applied, there is predicted to be no residual risk of injury during piling activities associated with the construction phase. In addition, the implementation of the MMMP as a designed in measure will further reduce the number of individuals affected further as they will be deterred beyond the predicted injury ranges.<br><br>The 160 dB rms strong disturbance contour does not extend to the Moray Firth SAC and therefore animals are unlikely to experience significant disturbance within the site (Figure 6.10). As per paragraph 551, the modelled noise contours that overlap with the Coastal East Scotland MU are above the threshold for mild disturbance (=140 dB rms), which could lead to mild disruptions of normal behaviours. However, as per Southall *et al.* (2021) prolonged or sustained behavioural effects, including displacement are unlikely to occur. Therefore, barrier effects are not predicted for the bottlenose dolphin feature of this MU or SAC. Piling will therefore not affect areas important for breeding and calving within the SAC, and therefore bottlenose dolphin will remain a viable component of the site. Overall, underwater noise generated during piling is not predicted to impact the population from being able to maintain itself as a viable component of the site over the long term. |
| | 2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance | The Array EIA Report (which used dose response) found that at the most conservative scenario for concurrent piling of the wind turbine (3,000 kJ) in the centre and OSPs (4,400 kJ) at the Northern limit of the site boundary, up to 2.23% of the Coastal East Scotland MU population could experience disturbance. Further, the results of the iPCoD modelling (which used dose response numbers) demonstrated that there would be no long term population effects. Disturbance due to underwater noise generated during piling is therefore not predicted to impact the distribution of bottlenose dolphin throughout the site. |
| | 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained | There is no pathway for impact between underwater noise generated during piling and the habitats and supporting processes of bottlenose dolphin. With respect to the availability of prey, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.3.4), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support bottlenose dolphin will not be adversely affected by this impact. |

554. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of underwater noise generated during piling in the construction phase of the Array alone.

## 6.3.2. UNDERWATER NOISE GENERATED DURING UXO CLEARANCE

555. The LSE[2] assessment during the HRA Stage One process identified that during the construction phase, LSE[2] could not be ruled out for underwater noise generated during UXO clearance. This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.

- Moray Firth SAC;
  - bottlenose dolphin.

556. The MDS and designed in measures considered for the assessment of underwater noise generated during UXO clearance are shown in Table 6.18 and Table 6.19, respectively.

**Table 6.18: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Underwater Noise Generated During UXO Clearance in the Construction Phase**

| Project Phase | MDS | Justification |
|---|---|---|
| Construction | UXO Clearance:<br>• clearance of up to 15 UXOs within the site boundary;<br>• *theoretical* maximum UXO size of up to 698 kg NEQ, realistic maximum weight of 227 kg NEQ;<br>• UXO clearance campaign will involve the use of up to 2 vessels on site at any one time with up to 4 return trips;<br>• intention for clearance of all UXOs using low order techniques (subsonic combustion) with a single donor charge of up to 0.25 kg NEQ for each clearance event;<br>• up to 0.5 kg NEQ clearance shot for neutralisation of residual explosive material at each location;<br>• up to 2 detonations within 24 hours;<br>• total duration of UXO clearance campaign 8 days excluding any time lost due to weather conditions; and<br>• clearance during daylight hours only. | Maximum number, theortetical and realistic maximum size of UXOs encountered within the site boundary is based on the UXO Hazard Assessment undertaken for the Array (Ordtek, 2022). Further detail on this is provided in Part 1 of the RIAA.<br><br>Donor charge is maximum required to initiate low order detonation. Assumption of a clearance shot of up to 0.5 kg at all locations, although noting that this may not always be required. |

**Table 6.19: Designed In Measures Considered for the Assessment of Potential Impacts to Annex II Marine Underwater Noise Generated During UXO Clearance in the Construction Phase**

| Designed In Measures | Justification | How the Designed In Measure will be Secured |
|---|---|---|
| The development of and adherence to a MMMP. | The MMMP will:<br>• mitigate for the risk of permanent auditory injury to marine mammals within a pre-defined 'mitigation zone' for each activity. The mitigation zone is determined considering the largest injury zone across all species for each relevant activity;<br>• reduce the potential injury to, marine mammals and other marine megafauna (e.g. basking shark and sea turtles) as far as practicable; and detail the visual and acoustic monitoring required as a minimum over the defined mitigation zones so that animals are clear before the activity commences. Additional measures to deter animals from injury risk zones may be applied in some instances (e.g. Acoustic Deterrent Devices (ADDs) or soft start charges).<br><br>An outline MMMP has been developed on the basis of the most recent published statutory guidance (JNCC, 2010a, JNCC, 2010c, JNCC, 2017) (volume 4, appendix 22 of the Array EIA Report). | Secured in the Section 36 Consent and/or Marine Licence via the requirement for a PS and associated MMMP which will be submitted to MD-LOT for approval. |
| Implementation of soft start measures for UXO clearance using a sequence of small explosive charges detonated over set time intervals. | These measures will reduce the likelihood of injury from elevated underwater noise to marine mammals in the immediate vicinity of piling/UXO clearance operations as far as practicable, allowing individuals to move away from the area before sound levels reach a level at which injury may occur. This is in line with the most up to date guidance for piling/UXO clearance operations (JNCC, 2010a; JNCC, 2010b) and, in most cases, compliance with this guidance reduce the likelihood of injury to marine mammal receptors to negligible levels. | UXO clearance will be subject to a separate Marine Licence application and EPS Licence as appropriate. Mitigation, including, implementation of low order disposal will be secured through the relevant Marine Licence and EPS licence. |
| UXO clearance using low order disposal techniques where technically feasible. | Low order techniques will be adopted wherever practicable (e.g. deflagration and clearance shots) as mitigation to reduce noise levels and thereby injury and disturbance to sound-sensitive receptors during UXO clearance. There is a small risk that low order disposal could unintentionally arise in a high order detonation and therefore this scenario has also been considered in the assessment of LSE[1]. | UXO clearance will be subject to a separate Marine Licence application and EPS Licence as appropriate. Mitigation, including, implementation of low order disposal will be secured through the relevant Marine Licence and EPS licence. |

### Information to support the assessment

Overview of underwater noise modelling conducted for the Array

557. Clearance of UXOs before construction begins could lead to effects from high order detonation of UXO (Table 6.18). This action has the capacity to produce some of the most elevated peak sound pressures among all human-made underwater noise sources and is recognised as a high-energy, impulsive noise source (von Benda-Beckmann *et al.*, 2015). The potential effects of this impact will vary based on the characteristics of the source, the species affected, proximity to the source and the degree of noise attenuation within the surrounding environment.

558. Further detail on underwater noise modelling of UXO clearance is provided in volume 3, appendix 10.1 of the Array EIA Report. In the case of high order detonation, acoustic modelling was conducted following the approach outlined in (Soloway *et al.*, 2014). The estimates are conservative, assuming the charge is freely positioned in mid-water, unlike a UXO resting on the seabed, which could experience burial, degradation, or significant attenuation. Additionally, the explosive material is likely to have deteriorated over time, making maximum noise levels probable overestimations of actual noise levels. Frequency-dependent weighting functions were applied to facilitate comparison with marine mammal hearing weighted thresholds.

559. As per Robinson *et al.* (2020), low order deflagration yields a considerably lower amplitude of peak sound pressure compared to high order detonations. Therefore, for low order clearance, underwater noise modelling has been based on the methodology outlined in paragraph 558, but with a smaller donor charge size.

560. Potential impacts of underwater noise resulting from UXO clearance on marine mammals could include mortality, physical injury, or auditory injury. The duration of potential impact (elevated noise) for each UXO detonation is very short (seconds) therefore behavioural effects are considered to be negligible in this context. As such, TTS represents a temporary auditory injury but can be also considered as a threshold for strong behavioural disturbance (for the onset of a moving away response) (see Table 6.6). A detailed underwater noise modelling assessment was carried out to investigate the potential PTS and TTS to occur, using the latest assessment criteria (volume 3, appendix 10.1 of the Array EIA Report). A project specific MMMP will be developed to mitigate the potential for injury (Table 6.19).

561. It is anticipated that up to 15 UXOs within the site boundary may require clearance. The maximum UXO size is assumed to be 698 kg NEQ and the most realistic maximum size is 227 kg NEQ (Table 6.18). A low order clearance donor charge of 0.25 kg NEQ is assumed for each clearance event and up to 0.5 kg NEQ clearance shot may be required for neutralisation of residual explosive material at each location. The clearance activities will be tide and weather dependent. The aim is to enable clearance of at least one UXO per tide, during the hours of daylight and good visibility.

562. Whilst the clearance of UXO can result in the high order detonation, in line with the UK Government *et al.* (2022) joint interim position statement, the Applicant commits to prioritise low order clearance techniques (Table 6.19). To ensure a precautionary approach, the assessment for auditory injury (PTS, paragraph 563 *et seq.*) and strong behavioural disturbance (using TTS onset as a proxy, paragraph 574 *et seq.*) is based on the high order clearance of maximum UXO (698 kg NEQ), however noting that the realistic maximum case NEQ of 227 kg is considered the more likely scenario (Table 6.18).

Injury (PTS)

563. It is considered that there is a small risk that a low order clearance could result in high order detonation of UXO and therefore the assessment considered both high order and low order techniques. With regard to UXO detonation (low order techniques as well as high order events), due to a combination of physical properties of high frequency energy, the noise is unlikely to still be impulsive in character once it has propagated more than a few kilometres (see volume 3, appendix 10.1 of the Array EIA Report for more details). The precise range at which this transition occurs is unknown, however the NMFS (2018) guidance suggests an estimate of 3 km for transition from impulsive to continuous. Hastie *et al.* (2019) suggest that some measures of impulsiveness change markedly within approximately 10 km of the source (for seismic surveys and piling). As such, caution should be used when interpreting any results with predicted injury ranges in the order of tens of kilometres as the PTS ranges are likely to be significantly lower than those predicted.

564. PTS ranges for low order clearance donor charge and clearance shot are presented in Table 6.20 and high order clearance of UXO presented in Table 6.21. The number of animals predicted to potentially experience PTS due to low order clearance donor charge and clearance shot is presented in Table 6.22 and high order clearance in Table 6.23.

565. A high order clearance of 698 kg NEQ yielded the largest PTS ranges for all species, with the greatest injury range (14,540 m) seen for harbour porpoise ($SPL_{pk}$) (Table 6.21). The PTS range as a result of the high order detonation of the realistic maximum case (227 kg NEQ) is reduced to 10,000 m for harbour porpoise ($SPL_{pk}$). Conservatively, the number of harbour porpoise that could be potentially injured, based on the site-specific seasonal peak density of 0.651 animals per $km^2$, was estimated as 433 animals for 698 kg NEQ UXO high order explosion ($SPL_{pk}$) equating to 0.12% of the North Sea MU (Table 6.23). Predicted numbers are smaller for the realistic maximum case UXO (227 kg NEQ) with up to 205 animals potentially experiencing PTS ($SPL_{pk}$) equating to 0.06 % of the North Sea MU Table 6.23). For low order clearance donor charge (0.25 kg NEQ) and clearance shot (0.5 kg NEQ), the PTS ranges of 1,050 m and 1,320 m were predicted (Table 6.20), which could injure up to three and four harbour porpoises, respectively (Table 6.22).

566. The underwater noise assessment found that the maximum injury (PTS) range estimated for bottlenose dolphin using the $SPL_{pk}$ metric is 840 m for the high order detonation of 698 kg NEQ, but this is reduced to 577 m for the realistic maximum case (227 kg NEQ) (Table 6.21). Given relatively low densities of bottlenose dolphin within the Array marine mammal study area, the high order detonation of 698 kg and 227 kg could result in injury for no more than one individual (Table 6.23). With reference to the wider population, this equated to small proportions of the relevant MU (less than 0.01%). For low order clearance donor charge (0.25 kg NEQ) and clearance shot (0.5 kg NEQ), the injury ranges were considerably lower with a maximum of 61 m and 77 m respectively (Table 6.20), and there would be no more than one animal potentially injured within these ranges (Table 6.22).

567. The maximum injury (PTS) range estimated for grey seal was 2,850 m using the $SPL_{pk}$ metric, for the high order detonation of 698 kg NEQ, but this was reduced to 1,960 m for 227 kg NEQ (Table 6.21). The number of individuals that could be potentially injured, based on average densities within the Array marine mammal study area from Carter *et al.* (2022), was estimated as up to five animals for 698 kg NEQ (Table 6.23), which equates to 0.01% of the East Scotland plus North-east England SMUs, and up to three animals for the realistic maximum design scenario (227 kg NEQ). For low order clearance donor charge (0.25 kg NEQ) and clearance shot (0.5 kg NEQ), the injury ranges were considerably lower with a maximum of 50 m and 259 m ($SPL_{pk}$), respectively (Table 6.20) and there would be no more than one animal potentially injured within these ranges (Table 6.22).

568. The auditory injury (PTS) ranges do not overlap with the Berwickshire and North Northumberland Coast SAC, Southern North Sea SAC, or the Moray Firth SAC.

**Table 6.20: Maximum PTS Ranges For Low Order Clearance Donor Charge and Clearance Shot (N/E = Threshold Not Exceeded)**

| Species (Hearing Group) | Metric | Threshold | PTS Range (m) | |
|---|---|---|---|---|
| | | | 0.25 kg NEQ | 0.5 kg NEQ |
| Harbour porpoise (VHF) | $SPL_{pk}$ | 202 dB re 1 µPa | 1,050 | 1,320 |
| | $SEL_{cum}$ | 155 dB re 1 µPa²s | 337 | 448 |
| Bottlenose dolphin (HF) | $SPL_{pk}$ | 230 dB re 1 µPa | 61 | 77 |
| | $SEL_{cum}$ | 185 dB re 1 µPa²s | N/E | N/E |
| Grey seal (PCW) | $SPL_{pk}$ | 218 dB re 1 µPa | 50 | 259 |
| | $SEL_{cum}$ | 185 dB re 1 µPa²s | N/E | 24 |

**Table 6.21: Maximum PTS Ranges for High Order Detonation of Maximum and Realistic Maximum Case**

| Species (Hearing Group) | Metric | Threshold | PTS Range (m) | |
|---|---|---|---|---|
| | | | 227 kg NEQ | 698 kg NEQ |
| Harbour porpoise (VHF) | $SPL_{pk}$ | 202 dB re 1 µPa | 10,000 | 14,540 |
| | $SEL_{cum}$ | 155 dB re 1 µPa²s | 2,930 | 3,710 |
| Bottlenose dolphin (HF) | $SPL_{pk}$ | 230 dB re 1 µPa | 577 | 840 |
| | $SEL_{cum}$ | 185 dB re 1 µPa²s | 83 | 139 |
| Grey seal (PCW) | $SPL_{pk}$ | 218 dB re 1 µPa | 1,960 | 2,850 |
| | $SEL_{cum}$ | 185 dB re 1 µPa²s | 437 | 745 |

**Table 6.22: Maximum Number of Animals With the Potential to Experience PTS Due to Low Order Clearance Donor Charge and Clearance Shot (N/A = Not Applicable As the Threshold Was Not Exceeded)**

| Metric | Number of Animals | | |
|---|---|---|---|
| | Harbour Porpoise | Bottlenose Dolphin | Grey Seal |
| **0.25 kg NEQ Charge Donor** | | | |
| $SPL_{pk}$ | 3 | <1 | <1 |
| $SEL_{cum}$ | <1 | N/A | N/A |
| **0.5 kg NEQ Clearance Shot** | | | |
| $SPL_{pk}$ | 4 | <1 | <1 |
| $SEL_{cum}$ | <1 | N/A | <1 |

**Table 6.23: Maximum Number of Animals With the Potential to Experience PTS Due to High Order Detonation of Maximum and Realistic Maximum Case (Prior to Any Mitigation)**

| Metric | Number of Animals | | |
|---|---|---|---|
| | Harbour Porpoise | Bottlenose Dolphin | Grey Seal |
| **227 kg NEQ** | | | |
| $SPL_{pk}$ | 205 | <1 | 3 |
| $SEL_{cum}$ | 18 | <1 | <1 |
| **698 kg NEQ** | | | |
| $SPL_{pk}$ | 433 | <1 | 5 |
| $SEL_{cum}$ | 29 | <1 | <1 |

569. With primary mitigation (i.e. using low order techniques, Table 6.19) in place the assessment found that there would be a risk of injury over a range of 1,050 m (for harbour porpoise using the $SPL_{pk}$ metric (Table 6.20). The injury range for clearance shot of 0.5 kg NEQ was predicted across a range of 1,320 m (Table 6.20).

570. However, if low order clearance is not feasible or accidentally results in high order detonation, there is a maximum risk of injury (predicted for harbour porpoise) out to 14,540 m during detonation of 698 kg NEQ and 10,000 km for a 227 kg NEQ. Therefore, in line with standard industry practice (JNCC, 2010a), tertiary mitigation will be applied as a part of the MMMP (Table 6.19). In line with stakeholder advice provided in response to Marine Mammal Consultation Note 2 (volume 2, chapter 10 of the Array EIA Report), the assessment with respect to PTS from UXO clearance will be based on both $SPL_{pk}$ and $SEL_{cum}$ injury ranges.

571. The maximum injury ranges presented in Table 6.20 and Table 6.21 are larger than the standard 1,000 m mitigation zone recommended for UXO clearance (JNCC, 2010a). The mitigation zone cannot be excessively large (e.g. a few km) as there may be difficulties in detecting marine mammals (particularly harbour porpoise) over large ranges (McGarry *et al.*, 2017) with a significant decline in visual detection rate with increasing sea state (Embling *et al.*, 2010, Leaper *et al.*, 2015).

572. Tertiary mitigation will therefore include the use of ADDs and scare charges to deter animals from the injury zone (Table 6.19). The efficacy of such deterrence will depend upon the device selected and reported ranges of effective deterrence vary. The reported effective deterrence range for harbour porpoise vary from 2.5 km out to 12 km (Brandt *et al.*, 2013, Dähne *et al.*, 2017, Kyhn *et al.*, 2015, Olesiuk *et al.*, 2002). A full review of available devices is provided in McGarry *et al.* (2022). In addition to the ADD use, deterrence can also be achieved through the use of soft start charges. Details of appropriate tertiary mitigation are discussed in the outline MMMP and will be discussed and agreed with consultees post-consent when further details of the size and type of potential UXOs are understood.

573. For harbour porpoise, the ranges of effect are large for high order clearance, and it is likely that following tertiary mitigation measures there will be a residual risk of PTS to a number of individuals (Table 6.23). To illustrate what this may entail for high order clearance of the realistic maximum case (227 kg NEQ), based on a conservative swim speed of 1.5 m/s for harbour porpoise (Table 6.5), a total of 112 minutes of deterrence activities would be required to allow animals to flee the injury range. Secondary mitigation is discussed in paragraphs 580 *et seq* which address the potential residual risk from a high order detonation.

Behavioural disturbance (TTS as a proxy)

574. As discussed in paragraph 560, the duration of effect for each UXO detonation is less than one second and therefore behavioural effects are considered to be negligible in this context. The assessment for behavioural disturbance uses the onset of TTS as a proxy. Although the effect would be a potential temporary loss in hearing and some ecological functions would be inhibited in the short term due to TTS, these are reversible on recovery of the animal's hearing and therefore not considered likely to lead to any long-term effects on the individual. The onset of TTS corresponds to a moving away or 'fleeing response' as this is the threshold at which animals experience disturbance and are likely to move away from the ensonified area. The onset of TTS is also considered to represent the boundary between the most severe disturbance levels and the start of physical auditory impacts on animals. Considering the above, the results of underwater noise modelling based on TTS onset as a proxy, will be hereinafter referred to as 'strong behavioural disturbance'.

575. Strong behavioural disturbance ranges for low order clearance donor charge and clearance shot are presented in Table 6.24 and high order clearance of UXO presented in Table 6.25. The largest ranges using $SPL_{pk}$ metric were predicted for clearance of the 698 kg NEQ with potential strong disturbance over a distance of up to 26,790 m for harbour porpoise (Table 6.25). Ranges predicted for other species using $SPL_{pk}$ only slightly exceeded 5 km for grey seal, with the largest strong behavioural disturbance range predicted at 5,250 m (Table 6.25). For harbour porpoise and bottlenose dolphin, the $SEL_{cum}$ metric yielded lower strong disturbance ranges during high order detonation than the $SPL_{pk}$ metric (Table 6.25). However, for grey seal, the maximum strong disturbance range of 6,120 m was modelled using the $SEL_{cum}$ metric for high order disposal, in contrast to the 5,250 m modelled using the $SPL_{pk}$ metric (Table 6.25). It should be noted that impulsive noise thresholds (TTS onset) were used in the underwater noise modelling for strong behavioural disturbance as a result of UXO clearance. As previously described in paragraph 563, the noise is unlikely to be impulsive in character once it has propagated more than a few kilometres and it is particularly important when interpreting results for disturbance within ranges larger than 10 km as these are likely to be significantly lower than predicted see (Hastie *et al.*, 2019) (see volume 3, appendix 10.1 of the Array EIA Report for more details).

**Table 6.24: Maximum Strong Behavioural Disturbance Ranges (TTS Used As a Proxy) For Low Order Clearance Donor Charge and Clearance Shot (N/E = Threshold Not Exceeded)**

| Species (Hearing Group) | Metric | Threshold | Strong Disturbance (TTS) Range (m) | |
|---|---|---|---|---|
| | | | 0.25 kg NEQ | 0.5 kg NEQ |
| Harbour porpoise (VHF) | $SPL_{pk}$ | 196 dB re 1 µPa (pk) | 1,930 | 2,435 |
| | $SEL_{cum}$ | 140 dB re 1 µPa²s | 2,120 | 2,510 |
| Bottlenose dolphin (HF) | $SPL_{pk}$ | 224 dB re 1 µPa | 112 | 141 |
| | $SEL_{cum}$ | 170 dB re 1 µPa²s | 43 | 60 |
| Grey seal (PCW) | $SPL_{pk}$ | 212 dB re 1 µPa | 378 | 477 |
| | $SEL_{cum}$ | 188 dB re 1 µPa²s | 232 | 320 |

**Table 6.25: Maximum Strong Behavioural Disturbance Ranges (TTS Used As a Proxy) for High Order Detonation of Maximum and Realistic Maximum Case**

| Species (Hearing Group) | Metric | Threshold | Strong Disturbance (TTS) Range (m) | |
|---|---|---|---|---|
| | | | 227 kg NEQ | 698 kg NEQ |
| Harbour porpoise (VHF) | $SPL_{pk}$ | 196 dB re 1 µPa (pk) | 18,425 | 26,790 |
| | $SEL_{cum}$ | 140 dB re 1 µPa²s | 7,515 | 8,720 |
| Bottlenose dolphin (HF) | $SPL_{pk}$ | 224 dB re 1 µPa | 1,065 | 1,550 |
| | $SEL_{cum}$ | 170 dB re 1 µPa²s | 870 | 1,310 |
| Grey seal (PCW) | $SPL_{pk}$ | 212 dB re 1 µPa | 3,610 | 5,250 |
| | $SEL_{cum}$ | 188 dB re 1 µPa²s | 4,265 | 6,120 |

576. The number of animals predicted to experience strong behavioural disturbance due to low order clearance donor charge and clearance shot is presented in Table 6.26 and high order clearance in Table 6.27. Given the largest strong behavioural disturbance ranges (Table 6.25) and precautionary peak seasonal site-specific densities (Table 6.3), the largest number of animals affected was found for harbour porpoise where up to 1,467 animals could experience strong disturbance as a result of high order detonation of a 698 kg NEQ (based on $SPL_{pk}$ metric, 0.42% of the North Sea MU population). Based on $SEL_{cum}$, the number of grey seal at risk of experiencing strong behavioural disturbance within a predicted 6,120 m disturbance range was estimated as 22 animals (0.06% of the East Scotland SMU plus the North-east England SMU). For bottlenose dolphin, the number of animals predicted to be disturbed was very small with no more than one animal within the predicted effect zones (Table 6.26, Table 6.27).

577. The strong behavioural disturbance ranges will not overlap with the Berwickshire and North Northumberland Coast SAC, Southern North Sea SAC, or the Moray Firth SAC.

**Table 6.26: Maximum Number of Animals With the Potential to Experience Strong Disturbance (TTS Used as a Proxy) Due to Low Order Clearance Donor Charge and Clearance Shot**

| Metric | Number of Animals | | |
|---|---|---|---|
| | Harbour porpoise | Bottlenose dolphin | Grey seal |
| **0.25 kg NEQ Charge Donor** | | | |
| $SPL_{pk}$ | 8 | <1 | <1 |
| $SEL_{cum}$ | 10 | <1 | <1 |
| **0.5 kg NEQ Clearance Shot** | | | |
| $SPL_{pk}$ | 13 | <1 | <1 |
| $SEL_{cum}$ | 13 | <1 | <1 |

**Table 6.27: Maximum Number of Animals With the Potential to Experience Strong Disturbance (TTS Used as a Proxy) Due to High Order Detonation of Maximum and Realistic Maximum Case**

| Metric | Number of Animals | | |
|---|---|---|---|
| | Harbour porpoise | Bottlenose dolphin | Grey seal |
| **227 kg NEQ** | | | |
| $SPL_{pk}$ | 694 | <1 | 8 |
| $SEL_{cum}$ | 116 | <1 | 11 |
| **698 kg NEQ** | | | |
| $SPL_{pk}$ | 1,467 | <1 | 16 |
| $SEL_{cum}$ | 155 | <1 | 22 |

578. Strong behavioural effects are reversible and therefore animals are anticipated to fully recover following cessation of the activity. It is, however, recognised that where tertiary mitigation applies to reduce the risk of auditory injury (PTS), the deterrence measures (i.e. ADD and soft start charges) by their nature would contribute to, rather than reduce, the moving away response.

579. As previously described in paragraph 562, the assessment considered the magnitude of a high order detonation for the MDS of 698 kg NEQ. The magnitude of disturbance resulting from a high order detonation is predicted to be of regional spatial extent, very short-term duration, intermittent and both the impact itself (i.e. the elevation in underwater noise during detonation event) and effect of disturbance is reversible (TTS represents a non-trivial disturbance but not permanent injury). It is predicted that the potential impact will affect the receptor directly, however, for all species a small proportion of the relevant MUs is predicted to be affected by strong behavioural disturbance. As such, whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects.

<u>Secondary mitigation and residual effect</u>

580. If required, secondary mitigation (i.e. ADD with a duration over 30 minutes) will be applied to further reduce the potential for injury to harbour porpoise occurring during UXO clearance (detailed in Table 6.19). Final mitigation required will be addressed post consent, in consultation with stakeholders, following more detailed information such as the size, number and quality of UXOs to be cleared (following site-investigation surveys), noting that it may be possible to reduce the ADD activation period and soft start procedure depending on the size and number of UXOs located within the Array. Paragraph 582 *et seq*. therefore details a worked example for mitigation based on the most significant predicted effect, and focused on harbour porpoise (as this is the species with a potential residual risk of injury), which considers the different timescales that would be required to clear the injury zone if ADD and soft-start is required.

581. As described in paragraph 562 *et seq*., low order techniques will be applied as the intended methodology for clearance of UXO, however there is a small risk that a low order clearance could result in high order detonation of UXO (as per paragraph 563 *et seq.*563). The secondary mitigation has been therefore tailored based on the size of the UXO and high order detonation scenario.

582. A range of UXO munitions sizes have been considered for the purpose of determining effective mitigation measures, up to a maximum scenario of a UXO size of 698 kg. This approach follows a similar strategy to that which was taken for Seagreen 1 Offshore Wind Farm EPS Risk Assessment and outline MMMP (volume 4, appendix 22) (Seagreen Wind Energy Ltd, 2021).

583. An outline MMMP (volume 4, appendix 22 of the Array EIA Report) has been developed for the purpose of mitigating the risk of auditory injury (PTS) to marine mammals from the proposed UXO clearance activities at the Array. This has been provided as a stand-alone document; however, this section provides an overview of the procedures for ADD and soft start, prior to making conclusions on the potential for residual effects and requirement for secondary mitigation.

584. The designed in measures included as a part of the outline MMMP (volume 4, appendix 22 of the Array EIA Report) (Table 6.19) are in line with JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010a). Details of ADD use and soft start charge application are specific for each of the anticipated UXO sizes. As discussed in paragraph 580, prior to the commencement of UXO clearance works, a more detailed assessment will be produced including an evaluation of the most appropriate measures to employ particularly with respect to emerging evidence on the use of scare charges as the most widely applied approach alongside ADDs. The approach to mitigating injury to marine mammals involves the monitoring of a 1 km radius mitigation zone in line with current guidance (JNCC, 2010a). Monitoring will be carried out by suitably qualified and experienced personnel within a mitigation team, comprising of two dedicated MMO[2] and one dedicated PAM operator. The purpose of this monitoring is to clear the mitigation zone of marine mammals prior to detonation.

585. Given the potential for auditory injury from high-order detonations for harbour porpoise and grey seal is at a greater range than can be mitigated by monitoring the 1 km zone (Table 6.21), an ADD will be deployed to deter marine mammals to a greater distance before any detonation. The assessment of effects provided in paragraph 563 *et seq.* determines the auditory injury range based on high order detonation of a 698 kg NEQ UXO (Table 6.21). At the time of writing, the actual number and size of the UXOs within the site boundary are unknown and therefore, the example secondary mitigation has been designed for a range of UXO munitions sizes so that the most appropriate approach can be applied to balance the risk of injury from UXO detonation with any additional noise introduced into the marine environment as deterrent measures.

586. Swim speeds are summarised in Table 6.5 along with the source papers for the assumptions. Therefore, the duration of the application of the ADD prior to UXO detonation will determine whether the animal can move out of the injury zone prior to UXO detonation. Activation of an ADD will commence within the 60 minutes pre-detonation search, providing no marine mammals have been observed within the mitigation zone for a minimum of 20 minutes. Example deterrence distances are provided for all Annex II marine mammals in Table 6.28.

587. Based on the UXO clearance flow chart (Figure 6.11; informed by Seagreen Wind Energy Ltd (2021)), for low order UXO size up to 0.25 kg NEQ, the required time of ADD activation is 12 minutes and this is expected to displace harbour porpoise to 1,080 m (exceeding the PTS distance of 1,050 m). If UXO size of up 0.5 kg NEQ is identified during the survey, then ADD will be activated for 15 minutes and this is expected to deter harbour porpoise to 1,350 m. For all other species, three minutes of ADD would be sufficient to deter the animals from the injury zone.

588. However, for high order UXO clearance, injury ranges are larger. Assuming the ADD is activated for an indicative 60 minutes (Table 6.28), the displacement distance for harbour porpoise would be 5,400 m, meaning there is a need to deter harbour porpoise from larger ranges that cannot be achieved using an ADD for 60 minutes duration alone (i.e. the injury zone exceeds 5,400 m). However, for all other species, a duration of 60 minutes ADD activation will be sufficient to deter animals from the injury zone up to the 698 kg NEQ (Table 6.28).

589. For high order UXO, to reduce the risk of PTS, there is a need to deter animals from larger ranges than can achieved using an ADD alone. Therefore, following an ADD activation period of up to 60 minutes, a 'soft start' will be undertaken, using a sequence of small explosive charges, detonated at five minutes intervals, over a total of maximum 20 minutes (Table 6.28, Figure 6.11). It is expected that up to 80 minutes of combined ADD/soft start procedure (up to 60 minutes of ADD and 20 minutes of soft start) will displace harbour porpoise to ranges of 7,200 m. Whilst this secondary mitigation is considered to be sufficient to deter most animals (noting that use of ADD alone deterred all other species from the injury zone), there may be a residual effect for harbour porpoise for this largest UXO size, as the maximum predicted PTS impact range for this species was 10,000 for the 227 kg NEQ and 14,580 m for 698 kg NEQ (Table 6.28).

Table 6.28: Recommended ADD Duration for Low Order and High Order UXO Clearance and Sizes, and Associated Displacement Distance

| UXO Size | Minimum Duration Prior to Detonation (Based on Harbour Porpoise) | Displacement Distance for Given Duration of ADD (m) | | |
|---|---|---|---|---|
| | | Harbour Porpoise | Bottlenose Dolphin | Grey seal |
| **Low order UXO** | | | | |
| Up to 0.25 kg NEQ | 12 min of ADD | 1,080 | 1,094 | 1,296 |
| Up to 0.5 kg NEQ | 15 min of ADD | 1,350 | 1,368 | 1,620 |
| **High order UXO** | | | | |
| Up to 227 kg NEQ (realistic maximum case) | 112 min of ADD | 10,080 | 10,214 | 12,096 |
| Up to 698 kg NEQ (maximum UXO size) | 162 min of ADD | 14,580 | 14,774 | 17,496 |
| **Indicative ADD durations** | | | | |
| 60 min of ADD only | | 5,400 | 5,472 | 6,480 |
| 60 min of ADD plus soft start charges for 20 minutes | | 7,200 | 7,296 | 8,640 |

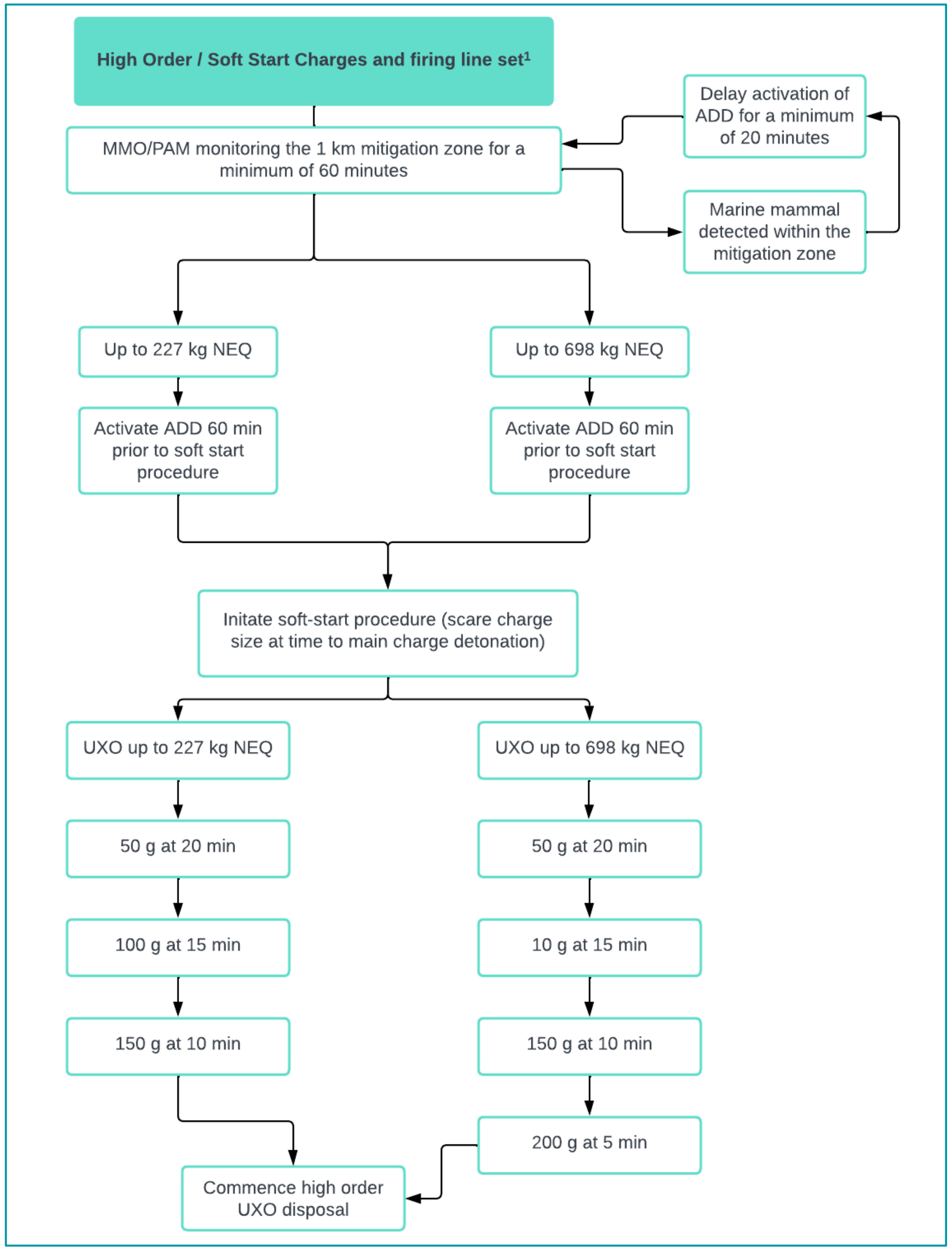


Figure 6.11: High Order UXO Clearance Mitigation Flow Chart for the Array ([1]Assuming UXO is not Suitable for Low Order Techniques)

590. The analysis presented in Table 6.28 suggests that for UXO sizes of up to 698 kg, pre-detonation search and use of ADD will be sufficient to reduce the potential of experiencing PTS by bottlenose dolphin and grey seal to negligible magnitude. However, it has been estimated that harbour porpoise could potentially experience an auditory injury at distances that cannot be fully mitigated by application of ADD and soft start charges. The maximum displacement distance has been assessed as 7,200 m and PTS range for this species has been modelled as 14,580 m.

591. To assess the residual effect, the average and maximum number of animals that may potentially be present within an area of 501 $km^2$ (difference between the area across which effects could be mitigated and area of effect) could be calculated using harbour porpoise density range (Table 6.21). However, this approach is considered likely to lead to an overestimate and may result in unrealistic predictions for the numbers of animals potentially injured. For example, for highly impulsive sounds such as piling, at ranges from the source in the order of tens of kilometres, the sound changes from being impulsive in character to being non-impulsive due to a combination of factors (e.g. dispersion of the waveform, multiple reflections from sea surface and seafloor, and molecular absorption of high frequency energy). Empirical evidence has suggested such shifts in impulsivity could occur markedly within 10 km from the source (Hastie *et al.*, 2019). Since the precise range at which this transition occurs is unknown (not least because the transition also depends on the response of the marine mammals' ear), models still adopt the impulsive thresholds at all ranges, and this is likely to lead to an overly precautionary estimate of injury ranges at larger distances (tens of kilometres) from the source. It is noted defining this transition range is an active area of research and scientific debate, with a number of other potential methods being investigated. Furthermore, at even greater ranges, the noise will not only be non-impulsive but can be characterised as being continuous (i.e. each pulse will merge into the next one and therefore is considered that any predicted injury ranges in the tens of kilometres are almost certainly an overly precautionary interpretation of existing criteria (Southall *et al.*, 2021)

592. There is also a likelihood that the range over which the animals are anticipated to be displaced during 60 minutes of ADD plus application of soft start charges is underestimated. Firstly, strong and far-reaching responses to an ADD have been recorded by Thompson *et al.* (2020) at approximately 10 km to the ADD source. Moreover, to assess the range of 7,200 m, an average harbour porpoise swim speed has been applied (i.e. 1.5 m/s). However various scientific papers provided significantly faster speeds with a maximum speed of 4.3 m/s and 6.2 m/s cited by Otani *et al.* (2000) and Leatherwood *et al.* (1988), respectively.

593. For harbour porpoise, it is expected that small numbers of animals could potentially be exposed to PTS. Given that details about UXO clearance technique to be used and charge sizes will not be available until after the consent is granted (pre-construction phase, following a UXO survey), it is not possible to quantify the effects of UXO detonations and therefore a residual number of animals potentially impacted is not presented within this Part of the RIAA. At a later stage, when details about UXO sizes and specific clearance techniques to be used become available, it will be possible to tailor the secondary mitigation to specific UXO sizes following the UXO survey and species to reduce the risk of injury.

594. Therefore, prior to the commencement of UXO clearance works, appropriate secondary mitigation measures will be discussed with stakeholders and proposed as a part the final MMMP for UXO clearance works. It is therefore anticipated that following the application of secondary mitigation measures following receipt of more detail regarding size and number of UXO (and tailoring of secondary mitigation measures as described), there will be no adverse effect on integrity of the SACs assessed with Annex II marine mammal features, particularly for harbour porpoise.

Construction phase

<u>Berwickshire and North Northumberland Coast SAC</u>

**Grey seal**

*Injury (PTS)*

595. As presented in paragraph 567, the maximum injury (PTS) range estimated for grey seal was 2,850 m using the $SPL_{pk}$ metric for the high order detonation of 698 kg NEQ. However, this was reduced to 1,960 m for 227 kg NEQ (Table 6.21). The number of individuals that could be potentially injured, based on average densities within the Array marine mammal study area from Carter *et al.* (2022), was estimated as up to five animals for 698 kg NEQ (Table 6.23), which equates to 0.01% of the East Scotland plus North-east England SMUs, and up to three animals for the realistic maximum design scenario (227 kg NEQ). For low order clearance donor charge (0.25 kg NEQ) and clearance shot (0.5 kg NEQ), the injury ranges were considerably lower with a maximum of 50 m and 259 m ($SPL_{pk}$), respectively (Table 6.20) and there would be no more than one animal potentially injured within these ranges (Table 6.22). The maximum auditory injury (PTS) range for grey seal (2,850 m) does not overlap with the Berwickshire and North Northumberland Coast SAC, which is a minimum of 113.95 km south-west from the site boundary.

596. Based on the maximum injury (PTS) range (estimated using the $SPL_{pk}$ metric) this potential impact would be localised within several kilometres of the detonation. UXO clearance would occur intermittently throughout the construction phase of the Array and be very short term. Although the potential impact itself is reversible (i.e. the elevation in underwater noise only occurs during the detonation event), the effect of PTS on grey seal is permanent. With tertiary mitigation applied (Table 6.19), it is anticipated that grey seal would be deterred from the injury zone and therefore the likelihood of PTS and population-level effects would be unlikely (paragraph 590).

*Behavioural disturbance (TTS as a proxy)*

597. As presented in paragraphs 574 to 579, the largest range of strong behavioural disturbance to grey seal (using TTS as a proxy) was predicted for clearance of the 698 kg NEQ using the $SEL_{cum}$ metric: 6,120 m (Table 6.25). The $SEL_{cum}$ metric yielded higher strong disturbance ranges during high order detonation than the $SPL_{pk}$ metric: 5,250 m (Table 6.25). It should be noted that impulsive noise thresholds (TTS onset) were used in the underwater noise modelling for strong behavioural disturbance as a result of UXO clearance. Based on $SEL_{cum}$, the number of grey seal at risk of experiencing strong behavioural disturbance within a predicted 6,120 m disturbance range was estimated as 22 animals (0.06% of the East Scotland SMU plus the North-east England SMU) (Table 6.26, Table 6.27). As previously described in paragraph 563, the noise is unlikely to be impulsive in character once it has propagated more than a few kilometres (Hastie *et al.*, 2019) (see volume 3, appendix 10.1 of the Array EIA Report for more details). The strong behavioural disturbance ranges will not overlap with the Berwickshire and North Northumberland Coast SAC (which is a minimum of 113.95 km south-west from the site boundary).

598. Kastelein *et al.* (2018b) measured recovery rates of harbour seal following exposure to a noise source of 193 dB re 1 $\mu Pa^2 s$ ($SEL_{cum}$) over 360 minutes and found that recovery from TTS to the pre-exposure baseline was estimated to be complete within 72 minutes following exposure. These results are in line with findings reported in SEAMARCO (2011), which showed that for small TTS values, recovery in seal species was very fast (around 30 minutes) and the higher the hearing threshold shift, the longer the recovery.

599. Considering the above, in most cases, impaired hearing for a short time is anticipated to have little effect on the total foraging period of a seal. If hearing is impaired for longer periods (hours or days) the potential impact has the potential to be ecologically significant (SEAMARCO, 2011). Nevertheless, the findings of studies presented in this section indicate that seal species are less vulnerable to TTS than harbour porpoise for the noise bands tested. It is also expected that grey seals would move beyond the injury range

prior to the onset of TTS. The assessment considered that grey seal is likely to be able to tolerate the effect without any potential impact on either reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased.

Conclusion

600. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise generated during UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.1) are discussed in turn below in Table 6.29.

**Table 6.29: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Underwater Noise Generated During UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for potential impact between underwater noise generated during UXO clearance and the extent, distribution, structure, and function of the habitats and supporting processes of grey seal (i.e. no overlap with the area of significant disturbance with the SAC). Therefore, the extent, distribution, structure, and function of habitats and supporting processes of grey seal will not be adversely affected by this impact. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | Overall, UXO clearance is unlikely to lead to injury or strong behavioural responses in grey seal. The assessment has concluded that this impact is highly unlikely to disrupt the population or distribution of grey seal associated with this SAC. The maximum injury (in terms of PTS) range estimated for grey seal was 2,850 m using the $SPL_{pk}$ metric for a high order detonation of 698 kg NEQ. At this range, up to five grey seal may be experience PTS (Table 6.23), which equates to 0.01% of the population of the relevant reference SMUs. Further, it was predicted that the designed in measure of ADD activation would result in no grey seal being affected by peak pressure ($SPL_{pk}$) as they would be able to flee the potential maximum injury range. Therefore, the populations and distribution of grey seal within this SAC are not likely to be impacted by injury (PTS) associated with UXO clearance, particularly at a population level.<br><br>Strong behavioural disturbance impacts (using TTS as a proxy) are predicted to be very short term and reversible, with impacted grey seal are anticipated to fully recover. The assessment determined that grey seal are likely to be able to tolerate short periods of strong behavioural disturbance without any potential impact on either reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased. Therefore, injury and disturbance from underwater noise generated during UXO clearance are not predicted to prevent the population or distribution of grey seal within the site from being maintained. |
| | The distribution of qualifying species within the site are maintained | |

601. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of underwater noise generated during UXO clearance in the construction phase of the Array alone.

Southern North Sea SAC

**Harbour porpoise**

*Injury (PTS)*

602. Scientific literature surrounding sensitivities to UXO clearance often focuses on harbour porpoise due to their very high sensitivity to noise. A study by von Benda-Beckmann *et al.* (2015) presented the range of effects of explosives on harbour porpoise in the southern North Sea; measures of SEL and peak overpressure (in kPa) were taken at distances up to 2 km from the explosions of seven aerial bombs detonated at approximately 26 m to 28 m depth, on a sandy substrate. Six bombs had a charge mass of 263 kg (580 lb) and one had a charge mass of 121 kg (267 lb). von Benda-Beckmann *et al.* (2015) investigated the potential for injury to occur as an ear trauma caused by the blast wave at a peak overpressure of 172 kPa (190 dB re. 1 µPa). In addition, the potential for noise-induced PTS to occur was based on a threshold of 190 dB re. 1 $\mu Pa^2s$ (PTS 'very likely to occur') and an onset threshold of 179 dB re. 1 $\mu Pa^2s$ (SEL) (PTS 'increasingly likely to occur') (Lucke *et al.* (2009) criteria). Results demonstrated the largest distance at which a risk of ear trauma could occur was at 500 m. They also found that noise-induced PTS was likely to occur greater than the 2 km range that was measured during the study since the SEL recorded at this distance was 191 dB re. 1 $\mu Pa^2s$, therefore 1 dB above the 'very likely to occur' threshold.

603. The study also modelled possible effect ranges for 210 explosions (of up to 1,000 kg charge mass) that had been logged by the Royal Netherland Navy and the Royal Netherlands Meteorological Institute over a two year period (2010 and 2011) (von Benda-Beckmann *et al.*, 2015). Validating the model using the empirical measurements of SEL out to 2 km, von Benda-Beckmann *et al.* (2015) found that the effect distances ranged between hundreds of metres to just over 10 km (for charges ranging from 10 kg up to 1,000 kg). Harbour porpoises are known to spend a large proportion of time near the surface (e.g. 55% based on Teilmann *et al.* (2007)) where the SEL was predicted to be lower, with effect distances for the onset of PTS just below 5 km. The authors caveat these results as, whilst the model could provide a reasonable estimate of the SEL within 2 km (given empirical measurements were made out to this point), estimates above this distance required further validation since the uncorrected model systematically overestimates SEL. More recently, Salomons *et al.* (2021) analysed sound measurements performed near two detonations of UXO (with charge masses of 325 kg and 140 kg). Subsequently a PTS effect distance in the range 2.5 km to 4 km was derived (Salomons *et al.*, 2021), using the weighted SEL values and threshold levels from Southall *et al.* (2019). When comparing the experimental data and model predictions, the same study concluded thar harbour porpoise are at risk of permanent hearing loss at distances of several kilometres, i.e. distance between 2 km and 6 km based on 140 kg and 325 kg charge masses, respectively (Salomons *et al.*, 2021). In 2019, 24 harbour porpoise were found dead following clearance of ground mines in the Baltic Sea in along the German coastline (Siebert *et al.*, 2022). The post-mortem examination found that in ten cases the cause of death was associated with a blast injury, however the charge masses of the explosives in this study are unknown.

604. As presented in paragraph 565, a high order clearance of 698 kg NEQ yielded the largest PTS ranges for harbour porpoise using the $SPL_{pk}$ metric (14,540 m) (Table 6.21). The PTS range from high order detonation of the realistic maximum case (227 kg NEQ) was reduced to 10,000 m for harbour porpoise ($SPL_{pk}$). Conservatively, the number of harbour porpoise that could be potentially injured, based on the site-specific seasonal peak density of 0.651 animals per $km^2$, was estimated as 433 animals for 698 kg NEQ UXO high order explosion ($SPL_{pk}$) equating to 0.12% of the North Sea MU (Table 6.23).

Predicted numbers are smaller for the realistic maximum design scenario UXO (227 kg NEQ) with up to 205 animals potentially experiencing PTS ($SPL_{pk}$) equating to 0.06 % of the North Sea MU Table 6.23). For low order clearance donor charge (0.25 kg NEQ) and clearance shot (0.5 kg NEQ), the PTS ranges of 1,050 m and 1,320 m were predicted (Table 6.20), which could injure up to three and four harbour porpoises, respectively (Table 6.22). The maximum auditory injury (PTS) range for harbour porpoise (14,540 m) does not overlap with the Southern North Sea SAC, which is a minimum of 129.86 km south-east from the site boundary.

605. The maximum injury ranges for harbour porpoise presented in Table 6.20 and Table 6.21 are larger than the standard 1,000 m mitigation zone recommended for UXO clearance (JNCC, 2010a). Therefore, tertiary mitigation will be applied as a part of the MMMP and has been discussed in paragraphs 569 to 573. Tertiary mitigation will include the use of ADDs and scare charges to deter animals from the injury zone (Table 6.19). In addition to the ADD use, deterrence can also be achieved through the use of soft start charges. However, given the large ranges of effect for harbour porpoise during high order clearance, it is likely that there will be a residual risk of PTS to a number of individuals after application of tertiary mitigation measures. Therefore, secondary mitigation has been discussed in paragraphs 580 *et seq.,* which address the potential residual risk from a high order detonation. Whilst it is complex to quantify the residual risk, it is anticipated that there may be a measurable change at an individual level. An MDS approach has been applied comprising clearance of up to 15 UXOs with low order techniques being prioritised, it is expected that UXO clearance would not manifest to population-level effects due to the small proportion of harbour porpoise within the North Sea MU potentially affected. Given that details about UXO clearance technique to be used and charge sizes will not be available until after the consent is granted (pre-construction phase, following a UXO survey), it is not possible to quantify the effects of UXO detonations and therefore a residual number of animals potentially impacted is not presented within this Part of the RIAA. The Array EIA Report anticipated that following the application of secondary mitigation measures upon receipt of more detail regarding size and number of UXO, the magnitude of this impact will be reduced to low for harbour porpoise. With the application of the secondary mitigation presented in paragraphs 580 *et seq.,* and given that only a small proportion of the North Sea MU population could potentially experience PTS or TTS, this residual impact was concluded to result in no adverse effect on integrity of the harbour porpoise feature of the Southern North Sea SAC.

*Behavioural disturbance (TTS as a proxy)*

606. Recovery rates of harbour porpoise were measured following exposure to a piling playback noise source of 175 dB re 1 μPa$^2$s (SEL) over 120 minutes (SEAMARCO, 2011). SEAMARCO (2011) found that recovery to the pre-exposure threshold was estimated to be complete within 48 minutes following exposure and the higher the hearing threshold shift, the longer the recovery. Further, Kastelein *et al.* (2021) found that the susceptibility to TTS depends on the frequency of the fatiguing noise causing the shift and the greatest TTS depends on the SPL (and related SEL).

607. In a series of studies reviewed in Finneran (2015), which measured TTS occurrence in harbour porpoise at a range of frequencies typical of high-amplitude anthropogenic sounds, the greatest shift in mean TTS occurred at 0.5 kHz with hearing recovery within 60 minutes after the fatiguing noise stopped. Scientific understanding of the biological effects of TTS is limited to the results of controlled exposure studies on small numbers of captive animals. Extrapolating these results to how animals may respond in the natural environment should be treated with caution as it is not possible to exactly replicate natural environmental conditions, and the small number of test subjects would not account for intraspecific differences (i.e. differences between individuals) or interspecific differences (i.e. extrapolating to other species) in response.

608. As presented in paragraphs 574 to 579, the largest range of strong behavioural disturbance to harbour porpoise (using TTS as a proxy) was predicted for clearance of the 698 kg NEQ using the $SPL_{pk}$ metric: 26,790 m (Table 6.25). The $SEL_{cum}$ metric yielded lower strong disturbance ranges during high order detonation than the $SPL_{pk}$ metric: 8,720 m (Table 6.25). It should be noted that impulsive noise thresholds (TTS onset) were used in the underwater noise modelling for strong behavioural disturbance as a result of UXO clearance. As previously described in paragraph 563, the noise is unlikely to be impulsive in character once it has propagated more than a few kilometres (Hastie *et al.*, 2019) (see volume 3, appendix 10.1 of the Array EIA Report for more details). Given the largest strong behavioural disturbance ranges (Table 6.25) and precautionary peak seasonal site-specific densities (Table 6.3), up to 1,467 harbour porpoise could experience strong disturbance as a result of high order detonation of a 698 kg NEQ (based on $SPL_{pk}$ metric, 0.42% of the North Sea MU population) (Table 6.26, Table 6.27). As per JNCC (2020) guidance, a 26 km EDR for UXO clearance is presented in Figure 6.12. This EDR is comparable to the disturbance range of 26,790 m modelled using TTS as a proxy (Table 6.25). The modelled strong behavioural disturbance ranges and the 26 km EDR will not overlap with the Southern North Sea SAC.

*Conclusion*

609. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise generated during UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.30.

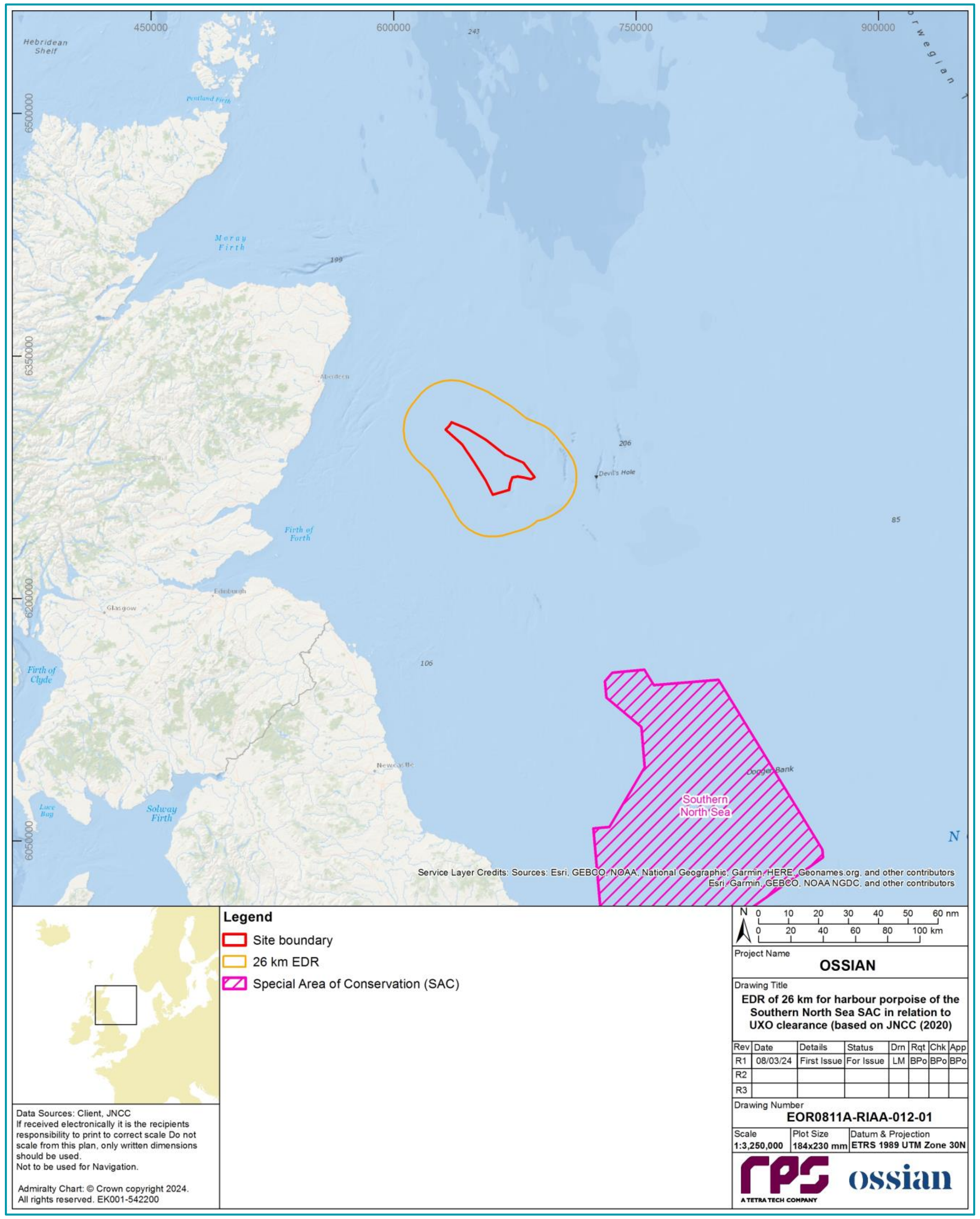


**Figure 6.12: EDR of 26 km for harbour porpoise of the Southern North Sea SAC in relation to UXO Clearance (based on JNCC (2020)**

**Table 6.30: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Underwater Noise Generated During UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site | Overall, UXO clearance may lead to auditory injury or strong behavioural responses to a small proportion of the North Sea MU population of harbour porpoise. The maximum injury (in terms of PTS) range estimated for harbour porpoise was 14,540 m using the $SPL_{pk}$ metric for a high order detonation of the absolute maximum 698 kg NEQ. At this range, up to 433 animals may experience PTS (Table 6.23), which equates to less than 0.12% of the population of the North Sea MU. However, following the implementation of designed in and secondary mitigation measures, the assessment concluded that this impact is unlikely to disrupt the population of harbour porpoise associated with this SAC. In addition, the maximum range of strong behavioural disturbance (using TTS as a proxy) was modelled out to 26,790 m for the high order clearance of 698 kg NEQ (using the $SPL_{pk}$ metric). This range is similar to the 26 km EDR for UXO clearance recommended in the JNCC (2020) guidance. This range does not extend to the SAC and therefore animals are unlikely to experience significant disturbance within the site. UXO clearance will therefore not affect areas important for breeding and calving within the SAC, and therefore harbour porpoise will remain a viable component of the site. Overall, following designed in and secondary mitigation measures, underwater noise generated during UXO clearance is not predicted to impact the population from being able to maintain itself as a viable component of the site over the long term. |
| | 2. There is no significant disturbance of the species | As noted in the row above, strong behavioural disturbance (using TTS as a proxy) was modelled out to 26,790 m for the high order clearance of 698 kg NEQ (using the $SPL_{pk}$ metric). This value is in line with the 26 km EDR recommended for UXO clearance in the JNCC (2020) guidance. Given that these ranges do not extend to the site (which is 129.86 km away), it is anticipated that there will be no significant disturbance to the harbour porpoise feature of the site. |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for impact between underwater noise generated during UXO clearance and the habitats and supporting processes of harbour porpoise. With respect to the availability of prey, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.3.4), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support harbour porpoise will not be adversely affected by this impact. |

610. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of underwater noise generated during UXO clearance in the construction phase of the Array alone.

Moray Firth SAC

**Bottlenose dolphin**

*Injury*

611. As presented in paragraph 566, the maximum injury (PTS) range estimated for bottlenose dolphin using the $SPL_{pk}$ metric was 840 m for the high order detonation of 698 kg NEQ. However, this was reduced to 577 m for the realistic maximum design scenario (227 kg NEQ) (Table 6.21). Given relatively low densities of bottlenose dolphin within the Array marine mammal study area and small injury ranges, the high order detonation of 698 kg and 227 kg could result in injury for no more than one animal (Table 6.23). With reference to the wider populations of the species, this equated to a small proportion of the Coastal East Scotland MU (less than 0.01%). For low order clearance donor charge (0.25 kg NEQ) and clearance shot (0.5 kg NEQ), the injury ranges were considerably lower with a maximum of 61 m and 77 m respectively (Table 6.20), and there would be no more than one animal potentially injured within these ranges (Table 6.22). The maximum auditory injury (PTS) range for bottlenose dolphin (840 m) does not overlap with the Moray Firth SAC, which is a minimum of 175.86 km north-west from the site boundary.

612. Based on the maximum injury (PTS) range (840 m; estimated using the $SPL_{pk}$ metric) this potential impact would be localised within one kilometre of the detonation. UXO clearance would occur intermittently throughout the construction phase of the Array and be very short term. Although the potential impact itself is reversible (i.e. the elevation in underwater noise only occurs during the detonation event), the effect of PTS on bottlenose dolphin is permanent. With tertiary mitigation applied (Table 6.19), it is anticipated that bottlenose dolphin would be deterred from the injury zone and therefore the likelihood of PTS and population-level effects would be unlikely (paragraph 590).

*Behavioural disturbance (TTS as a proxy)*

613. As presented in paragraphs 574 to 579, the largest range of strong behavioural disturbance to bottlenose dolphin (using TTS as a proxy) was predicted for clearance of the 698 kg NEQ using the $SPL_{pk}$ metric: 1,550 m (Table 6.25). The $SEL_{cum}$ metric yielded slightly lower disturbance ranges during high order detonation than the $SPL_{pk}$ metric: 1,310 m (Table 6.25). For bottlenose dolphin, the number of animals predicted to be disturbed was very small with no more than one animal within the predicted effect zones (Table 6.26, Table 6.27). It should be noted that impulsive noise thresholds (TTS onset) were used in the underwater noise modelling for strong behavioural disturbance as a result of UXO clearance. As previously described in paragraph 563, the noise is unlikely to be impulsive in character once it has propagated more than a few kilometres (Hastie *et al.*, 2019) (see volume 3, appendix 10.1 of the Array EIA Report for more details). The strong behavioural disturbance ranges will not overlap with the Moray Firth SAC.

614. Finneran *et al.* (2000) investigated the behavioural and auditory responses of two captive bottlenose dolphin to noise that simulated distant underwater explosions. The animals were exposed to an intense noise once per day and no auditory shift (i.e. TTS) greater than 6 dB in response to levels up to 221 dB re 1 µPa peak-to-peak (p-p) was observed. Behavioural shifts, such as delaying approach to the test station and avoiding the 'start' station, were recorded at 196 dB re 1 µPa p-p and 209 dB re 1 µPa p-p for the two bottlenose dolphin and continued at higher levels. However, there are several caveats to this study as discussed in Nowacek *et al.* (2007), with the signals used in this study distant and the study measured masked-hearing signals. The animals used in the experiment were also trained and rewarded for tolerating high levels of noise and subsequently, it can be anticipated that behavioural disruption would likely be observed at lower levels in other contexts.

615. Whilst there are no available species-specific recovery rates for HF cetaceans to TTS, there is no evidence to suggest that recovery will be significantly different to harbour porpoise recovery rates (paragraphs 606 and 606), therefore animals can recover their hearing after they are no longer exposed to elevated noise levels. It can be anticipated that bottlenose dolphin would be able to tolerate the effect without any impact on reproduction or survival rates with the ability to return to previous behavioural states or activities once the impacts had ceased.

*Conclusion*

616. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of underwater noise generated during UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.31.

**Table 6.31: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Underwater Noise Generated During UXO Clearance in the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site | Overall, UXO clearance is unlikely to lead to auditory injury or strong behavioural responses to bottlenose dolphin. The assessment has concluded that this impact is highly unlikely to disrupt the population of bottlenose dolphin associated with this SAC or result in any barrier effects. The maximum injury (in terms of PTS) range estimated for bottlenose dolphin was 840 m using the $SPL_{pk}$ metric for an absolute maximum high order detonation of 698 kg NEQ. At this range, no more than one bottlenose dolphin may experience PTS (Table 6.23), which equates to less than 0.01% of the population of the Coastal East Scotland MU. Furthermore, it was predicted that the designed in measure of ADD activation would result in no bottlenose dolphin being affected by peak pressure ($SPL_{pk}$) as they would be able to flee the potential maximum injury range. In addition, the maximum range of strong behavioural disturbance (using TTS as a proxy) was modelled out to 1,550 m for the high order clearance of 698 kg NEQ (using the $SPL_{pk}$ metric). This range does not extend to the Moray Firth SAC and therefore animals are unlikely to experience significant disturbance within the site. UXO clearance will therefore not affect areas important for breeding and calving within the SAC, and therefore bottlenose dolphin will remain a viable component of the site. Overall, underwater noise generated during UXO clearance is not predicted to impact the population from being able to maintain itself as a viable component of the site over the long term. |
| | 2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance | As noted in the row above, strong behavioural disturbance (using TTS as a proxy) was modelled out to 1,550 m for the high order clearance of 698 kg NEQ (using the $SPL_{pk}$ metric). Given that this does not extend to the site (which is 175.86 km away), it is anticipated that significant disturbance of the bottlenose dolphin feature of the site will be avoided. Therefore, disturbance due to underwater noise generated during UXO clearance is not predicted to impact the distribution of bottlenose dolphin throughout the site. |
| | 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained | There is no pathway for potential impact between underwater noise generated during UXO clearance and the habitats and supporting processes of bottlenose dolphin. With respect to the availability of prey, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.3.4), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support bottlenose dolphin will not be adversely affected by this impact. |

617. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of underwater noise generated during UXO clearance in the construction phase of the Array alone.

### 6.3.3. INJURY AND DISTURBANCE DUE TO SITE-INVESTIGATION SURVEYS (INCLUDING GEOPHYSICAL SURVEYS)

618. The LSE[2] assessment during the HRA Stage One process identified that during the construction and operation and maintenance phases, LSE[2] could not be ruled out for injury and disturbance due to site-investigation surveys (including geophysical surveys). This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

619. The MDS and designed in measures considered for the assessment of injury and disturbance due to site-investigation surveys (including geophysical surveys) are shown in Table 6.32 and Table 6.33 respectively.

**Table 6.32: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Injury and Disturbance due to Site-Investigation Surveys (Including Geophysical Surveys) during the Construction and Operation and Maintenance Phases**

| Project Phase | MDS | Justification |
|---|---|---|
| Construction | Geophysical surveys will include:<br>• Multibeam Echosounder (MBES);<br>• Magnetometer (MAG);<br>• Side-scan sonar (SSS);<br>• Sub-bottom profiler (SBP); and<br>• Two Dimensional (2D) Ultra High-Resolution Seismic (UHRS).<br><br>Geotechnical surveys will include:<br>• Cone Penetration Test (CPT);<br>• vibrocore;<br>• piston core;<br>• box core; and<br>• borehole.<br><br>Geophysical and geotechnical surveys will involve the use of up to 4 vessels on site at any one time with up to 50 vessel movements in total and will take place for 5 months over a 3 year period. | Maximum range of geophysical and geotechnical activities likely to be undertaken using equipment typically employed for these types of surveys will result in the greatest potential impact. |
| Operation and maintenance | Geophysical surveys will include:<br>• MBES; and<br>• SBP.<br><br>Geophysical surveys will involve the use of up to 8 unmanned surface vehicles with one return trip each or 1 manned vessel with up to 2 return trips.<br><br>Routine geophysical surveys will take place:<br>• once every 24 months for wind turbines and OSP foundations as well as wind turbines interior and exterior; and<br>• annually for the first 3 years, then every 24 months for inter-array cables and interconnector cables.<br><br>Duration of routine geophysical survey campaign is up to 3 months | |

**Table 6.33: Designed In Measures Considered for the Assessment of Potential Impacts to Annex II Marine Mammals to Injury and Disturbance due to Site-Investigation Surveys (Including Geophysical Surveys) during the Construction and Operation and Maintenance Phases**

| Designed In Measures | Justification | How the Designed In Measure will be Secured |
|---|---|---|
| The development of and adherence to a MMMP. The MMMP will present appropriate mitigation for activities that could potentially lead to injurious effects on marine mammals including piling, UXO clearance and some types of geophysical activities. The MMMP will be developed on the basis of the most recent published statutory guidance and in consultation with key stakeholders (JNCC, 2010a, JNCC, 2010c, JNCC, 2017).<br><br>For geophysical surveys, measures will include setting a mitigation zone of at least 500 m in line with current guidance (JNCC, 2017), with the extent of the mitigation zone informed by the largest injury range across all types of geophysical surveys. Mitigation during geophysical surveys will involve visual and acoustic monitoring using MMO[2] and PAM so that the risk of injury over the defined mitigation zone is reduced in line with JNCC guidance (JNCC, 2017). Soft starts will be applied for electromagnetic equipment (such as SBP and SSS) as well as seismic sources (UHRS). As per the JNCC (2017) MBES surveys in shallow waters (<200 m) are not subject to the requirements of mitigation therefore no mitigation will be proposed to this type of survey. | The MMMP will:<br>• mitigate for the risk of permanent auditory injury to marine mammals within a pre-defined 'mitigation zone' for each activity. The mitigation zone is determined considering the largest injury zone across all species for each relevant activity;<br>• reduce the potential injury to, marine mammals and other marine megafauna (e.g. basking shark and sea turtles) as far as practicable; and detail the visual and acoustic monitoring required as a minimum over the defined mitigation zones so that animals are clear before the activity commences. Additional measures to deter animals from injury risk zones may be applied in some instances (e.g. ADD or soft start charges).<br><br>An outline MMMP has been developed on the basis of the most recent published statutory guidance (JNCC, 2010a, JNCC, 2010c, JNCC, 2017). | Secured in the Section 36 Consent and/or Marine Licence via the requirement for a PS and associated MMMP which will be submitted to MD-LOT for approval. |

Information to support the assessment

Overview of underwater noise modelling conducted for the Array

620. Site-investigation surveys during the construction and operation and maintenance phases of the Array have the potential to cause direct or indirect effects (including injury or disturbance) on Annex II marine mammals.

621. A detailed underwater noise modelling assessment has been carried out to investigate the potential for injurious and behavioural effects on marine mammals as a result of geophysical and geotechnical surveys, using the latest noise criteria (see volume 3, appendix 10.1 of the Array EIA Report). Several sonar-like sources will potentially be used for the geophysical surveys, including MBES, SSS, SBP and UHRS. The equipment likely to be used can typically work at a range of signal frequencies, depending on the distance to the seabed and the required resolution. For sonar-like sources the signal is highly directional, acts like a beam and is emitted in pulses. Sonar-like sources are considered by the NMFS (2018) as continuous (non-impulsive) because they generally comprise a single (or multiple discrete) frequency. Unlike the sonar-like survey sources, the UHRS is likely to utilise a sparker, which produces an impulsive, broadband source signal. Additionally, MAG will be used to measure and detect anomalies within the existing magnetic field. The survey parameters, such as source SEL, used in the underwater noise modelling are presented in detail in volume 3, appendix 10.1 of the Array EIA Report. For geotechnical surveys, potential equipment to be used include CPT, vibrocore, piston core, box core and borehole (Table 6.32).

Auditory injury (PTS)

622. As detailed in volume 3, appendix 10.1 of the Array EIA Report, Injury ranges for impulsive survey sources (UHRS, CPT) are based on a comparison to the Southall *et al.* (2019) thresholds for impulsive noise (with the distances presented in brackets for $SPL_{pk}$ thresholds) whereas non-impulsive survey sources (MBES, SSS, SBP, borehole, vibrocore) results are compared against the non-impulsive thresholds. It should be noted that for impulsive noise, the injury ranges were larger for the $SEL_{cum}$ metric compared to $SPL_{pk}$ (Table 6.34, Table 6.35).

623. The maximum injury (PTS) range across all geophysical surveys was estimated as 310 m for harbour porpoise due to SBP activity (Table 6.34). For bottlenose dolphin and grey seal the maximum PTS is expected to occur out to 75 m (Table 6.34). However, it should be noted that as sonar-like sources have very strong directivity, there is only potential for injury when an animal is directly underneath the noise source. Once the animal moves outside of the main beam, there is no potential for injury.

624. With respect to the ranges within which there is a potential of PTS occurring to marine mammals because of geotechnical investigation activities, the PTS threshold was not exceeded for all species, except harbour porpoise (Table 6.35). Harbour porpoise are at risk of potential injury within 45 m from the noise source during the CPT activity (Table 6.35).

625. The number of marine mammals potentially injured within the modelled PTS ranges (Table 6.34, Table 6.35) were estimated using species-specific density estimates (Table 6.36). Given that the potential PTS ranges are relatively low, no more than one animal of each species is at risk of experiencing PTS across all types of geophysical and geotechnical surveys (Table 6.36).

626. The auditory injury (PTS) ranges will not overlap with the Berwickshire and North Northumberland Coast SAC, Southern North Sea SAC, or the Moray Firth SAC.

**Table 6.34: Potential Injury (PTS) Impact Ranges (m) For Geophysical Site-Investigation Surveys (N/E = Threshold Not Exceeded, Comparison to Ranges for $SPL_{pk}$ Where Threshold was Exceeded Shown in Brackets)**

| Survey Type | Potential PTS Impact Range (m) | | |
|---|---|---|---|
| | Harbour Porpoise | Bottlenose Dolphin | Grey Seal |
| MBES | 75 | 65 | 5 |
| SSS | 75 | 75 | 25 |
| SBP | 310 | 75 | 75 |
| UHRS | 10 (19) | N/E | N/E |

**Table 6.35: Potential Injury (PTS) Impact Ranges (m) For Geotechnical Site-Investigation Surveys (N/E = Threshold Not Exceeded, Comparison to Ranges for $SPL_{pk}$ Where Threshold was Exceeded Shown in Brackets)**

| Survey Type | Potential PTS Impact Range (m) | | |
|---|---|---|---|
| | Harbour Porpoise | Bottlenose Dolphin | Grey Seal |
| Borehole drilling | N/E | N/E | N/E |
| CPT | 45 (11) | N/E | N/E |
| Vibrocoring | N/E | N/E | N/E |

**Table 6.36: Estimated Number of Animals with the Potential To Experience Injury (PTS) During Geophysical and Geotechnical Site-Investigation Surveys (Number of Animals Based on $SPL_{pk}$ Where Threshold was Exceeded Shown in Brackets)**

| Survey Type | Estimated Number of Animals with the Potential to Experience Injury (PTS) | | |
|---|---|---|---|
| | Harbour Porpoise | Bottlenose Dolphin | Grey Seal |
| **Geophysical Surveys** | | | |
| MBES | <1 | <1 | <1 |
| SSS | <1 | <1 | <1 |
| SBP | <1 | <1 | <1 |
| UHRS | <1 (<1) | N/A | N/A |
| **Geotechnical Surveys** | | | |
| Borehole drilling | N/A | N/A | N/A |
| CPT | <1 (<1) | N/A | N/A |
| Vibrocoring | N/A | N/A | N/A |

627. The site-investigation surveys are considered to be short term as they will take place over a period of up to five months as per the MDS (Table 6.32). In line with best practice guidance, designed in measures during geophysical surveys will involve the use of MMO[2] and PAM to ensure that the risk of injury over the defined mitigation zone is reduced (JNCC, 2017) (Table 6.33). The largest PTS range was estimated as 310 m for harbour porpoise exposed to SBP and it is considered that standard industry measures will be effective at reducing the risk of injury over this distance (JNCC, 2017). Since the risk of injury is assumed to be fully mitigated via designed in measures there is considered to be no residual risk of injury and therefore no population-level effects for any species.

Behavioural disturbance

628. It is widely recognised that the transmission frequencies of commercial sonar systems (approximately 12 kHz to 1800 kHz) overlap with the hearing ranges of many marine mammal species (Richardson *et al.*, 1995). Many frequencies associated with sonar systems are very high and have peak frequencies well above marine mammal hearing ranges, however it is possible that relatively high levels of sound are also produced as sidebands at lower frequencies (Hayes *et al.*, 1992) and therefore may result in behavioural responses. Aside from displacement or avoidance, other behavioural responses have been demonstrated (Wright *et al.*, 2015). Responses to seismic surveys have included cessation of singing (Melcón *et al.*, 2012) and alteration of dive and respiration patterns which may lead to energetic burdens on the animals (Gordon *et al.*, 2003). In some cases, behavioural responses may lead to greater effects, such as strandings (Cox *et al.*, 2006, Tyack *et al.*, 2006) or interruptions to migration (Heide-Jørgensen *et al.*, 2013). However such responses are highly context-dependent and variable, contingent on factors such as the activity of the animal at the time (Robertson, 2014), prior experience to exposure (Andersen *et al.*, 2012), extent or type of disturbance (Melcón *et al.*, 2012), environment in which they inhabit (Heide-Jørgensen *et al.*, 2013) and the type of survey.

629. For impulsive noise sources (UHRS, CPT) the underwater noise modelling adopted the NMFS (2005) thresholds of 140 dB re 1 µPa for mild disturbance and 160 dB re 1 µPa for strong disturbance. For non-impulsive noise sources (MBES, SSS, SBP, borehole, vibrocore) the underwater noise modelling used the NMFS (2005) threshold of 120 dB re 1 µPa for continuous noise. The underwater noise modelling predicted that behavioural disturbance due to non-impulsive site-investigation survey equipment could occur within a range of between 27 m (borehole drilling) and up to 9,101 m (vibrocoring) for all species (Table 6.37). Potential disturbance ranges were 320 m, 375 m, and 1,340 m for SSS, MBES, and SBP, respectively (Table 6.37).

630. For impulsive noise sources (UHRS, CPT) the strong behavioural disturbance ranges vary from 80 m during UHRS to 140 m during CPT (Table 6.37). Qualitatively, no more than one animal of each species would be at risk of experiencing strong behavioural disturbance. Mild disturbance may occur within 565 m during UHRS to 1,330 m during CPT and for all species no more than one animal could be affected (Table 6.38). Up to four harbour porpoise could experience mild behavioural disturbance during CPT (Table 6.38), however, such low level disturbance could lead to mild disruptions of normal behaviours, but prolonged or sustained behavioural effects, including displacement are unlikely to occur.

631. For non-impulsive noise sources (MBES, SSS, SBP, borehole drilling, vibrocore), the maximum behavioural disturbance ranges vary from 27 m to the maximum 9,101 m for vibrocoring (Table 6.37). Qualitatively, no more than one animal is predicted to be disturbed during MBES, SSS and borehole drilling. With the use of SBP, up to four harbour porpoise, two grey seal, and one bottlenose dolphin are at risk of experiencing disturbance. Due to relatively large disturbance ranges predicted for vibrocoring, based on conservative species-specific densities, up to 170 harbour porpoises could experience disturbance (Table 6.38). Vibrocoring may also lead to disturbance of up to one bottlenose dolphin and 47 grey seal (Table 6.38).

632. However, for those animals disturbed, there is likely to be a proportional response, e.g. not all animals will be disturbed to the same extent. There is no dose-response curve available to apply in the context of site-investigation surveys, however, Joy *et al.* (2019) derived a dose-response for killer whales and underwater noise from vessels, indicating that marine mammals display a proportional response to non-impulsive noise. It is important to note that the life history of an individual and the context will also influence the likelihood of an individual to exhibit an aversive response to noise. Furthermore, this threshold does not take into account of ambient sound levels in the area, which may be already be above the 120 dB re 1 µPa (Farcas *et al.*, 2020). Considering that the underwater noise modelling used a single threshold that does not take into account the ambient noise, the numbers of animals potentially disturbed presented for vibrocore and other site-investigation surveys are likely to be an overestimate.

633. The behavioural disturbance ranges presented in Table 6.37 will not overlap with the Berwickshire and North Northumberland Coast SAC, Southern North Sea SAC, or the Moray Firth SAC.

634. The effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). Whilst there may be minor effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects for any species.

**Table 6.37: Potential Disturbance Ranges For Geophysical and Geotechnical Site-Investigation Surveys**

| Metric | Potential Disturbance Range (m) For All Species |
|---|---|
| **Geophysical Surveys** | |
| MBES | 375 |
| SSS | 320 |
| SBP | 1,340 |
| UHRS | 565 (mild), 80 (strong) |
| **Geotechnical Surveys** | |
| Borehole drilling | 27 |
| CPT | 1,330 (mild), 140 (strong) |
| Vibrocoring | 9,101 |

**Table 6.38: Estimated Number of Animals With the Potential To Be Disturbed During Geophysical and Geotechnical Site-Investigation Surveys**

| Survey Type | Estimated Number of Animals with the Potential to Be Disturbed | | |
|---|---|---|---|
| | Harbour Porpoise | Bottlenose Dolphin | Grey Seal |
| **Geophysical Surveys** | | | |
| MBES | <1 | <1 | <1 |
| SSS | <1 | <1 | <1 |
| SBP | 4 | <1 | 2 |
| UHRS | <1 | <1 | <1 |
| **Geotechnical Surveys** | | | |
| Borehole drilling | N/A | N/A | N/A |
| CPT | 4 | N/A | N/A |
| Vibrocoring | 170 | <1 | 47 |

### Construction and operation and maintenance phases

635. The site-investigation surveys as listed in Table 6.32 for the construction phase will involve the use of up to four survey vessels with up to 50 vessel movements in total. The site-investigation surveys will be carried out over five months within a three year period.

636. In the operation and maintenance phase, the MDS comprises of routine geophysical surveys such as MBES and SBP (Table 6.32). Routine geophysical surveys will take place once every 24 months for wind turbines and OSP foundations, as well as wind turbines interior and exterior and annually for the first 3 years, then every 24 months for inter-array cables and interconnector cables. The duration of each operation and maintenance geophysical survey campaign will be up to 3 months (Table 6.32).

637. The modelling presented in paragraphs 620 *et seq.* is applicable to activities across both the construction and operation and maintenance phases, which have been combined here and to avoid repetition.

Berwickshire and North Northumberland Coast SAC

Grey seal

Injury

638. An overview of potential auditory injury due (PTS) to elevated underwater noise during site-investigation surveys is described in paragraph 620 *et seq.* and is applicable to construction and operation and maintenance phase activities. As detailed in Table 6.34, the modelled PTS impact ranges were low for grey seal for geophysical site investigation techniques. The threshold was not exceeded for UHRS, and ranged from 5 m (MBES), 25 m (SSS), and 75 m (SBP) for the other geophysical survey techniques. Based on these modelled injury ranges, no more than one grey seal from the relevant SMUs would have the potential to experience PTS as a result of MBES, SSS, and SBP, and none for UHRS (Table 6.36).

639. As detailed in Table 6.35, the PTS impact range for grey seal will not be exceeded for any of the geotechnical site investigation survey techniques: borehole drilling, CPT, and vibrocoring, and therefore no animals will potentially be impacted as a result (Table 6.36). The PTS ranges for any geophysical and geotechnical survey equipment will not overlap with the Berwickshire and North Northumberland Coast SAC, which is a minimum of 113.95 km south-west from the site boundary.

640. Overall, since the risk of injury is assumed to be fully mitigated via designed in measures (Table 6.33) there is considered to be no residual risk of injury and therefore no population-level effects for grey seal.

Behavioural disturbance

641. An overview of potential behavioural disturbance due to elevated underwater noise during site-investigation surveys is described in paragraph 628 *et seq.* and is applicable to construction and operation and maintenance phase activities.

642. For impulsive noise sources (UHRS, CPT), as mentioned in paragraph 451, the underwater noise modelling adopted the NMFS (2005) thresholds of 140 dB re 1 µPa for mild disturbance and 160 dB re 1 µPa for strong disturbance. For non-impulsive noise sources (MBES, SSS, SBP, borehole, vibrocore) the underwater noise modelling used the NMFS (2005) threshold of 120 dB re 1 µPa for continuous noise.

643. For impulsive noise sources (UHRS and CPT) the strong behavioural disturbance ranges vary from 80 m during UHRS to 140 m during CPT for all species (Table 6.37). Quantitively, no more than one grey seal would be at risk of experiencing strong behavioural disturbance as a result. Mild disturbance may occur within 565 m during UHRS to 1,330 m during CPT for all species, and no more than one grey seal could be affected as a result (Table 6.38).

644. The underwater noise modelling predicted that behavioural disturbance due to non-impulsive site-investigation survey equipment could occur within a range of between 27 m (borehole drilling) and up to 9,101 m (vibrocoring) for all species (Table 6.37). Potential disturbance ranges were 320 m, 375 m, and 1,340 m for SSS, MBES, and SBP, respectively (Table 6.37). Quantitively, no more than one grey seal is predicted to be disturbed during MBES, SSS and borehole drilling (Table 6.38). With the use of SBP, up to two grey seal are at risk of experiencing disturbance. Due to relatively large disturbance ranges predicted for vibrocoring, based on conservative species-specific densities, up to 47 grey seal could experience disturbance (Table 6.38).

645. However, as described in paragraph 632, the numbers of animals potentially disturbed for vibrocore and other site-investigation surveys are likely to be an overestimate.

646. The behavioural disturbance ranges will not overlap with the Berwickshire and North Northumberland Coast SAC, which is 113.95 km south-west of the site boundary.

647. The effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). Whilst there may be minor effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects for the grey seal feature of the Berwickshire and North Northumberland Coast SAC.

Conclusion

648. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of injury and disturbance due to site-investigation surveys during the construction and operation and maintenance phases. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.1) are discussed in turn below in Table 6.39.

**Table 6.39: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Injury and Disturbance due to Site-Investigation Surveys (Including Geophysical Surveys) during the Construction and Operation and Maintenance Phases of the Array Alone**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for potential impact between this site-investigation surveys and the extent, distribution, structure, and function of the habitats and supporting processes of grey seal (i.e. no overlap with the area of significant disturbance with the SAC). Therefore, the extent, distribution, structure, and function of the habitats and supporting processes that support grey seal will not be adversely affected by this impact. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | Overall, site-investigation surveys in the construction and operation and maintenance phases of the Array are unlikely to lead to auditory injury or strong behavioural responses to grey seal. The maximum injury (in terms of PTS) range estimated for grey seal was 75 m using the $SPL_{pk}$ metric for SBP equipment. At this range, up to one animal may experience PTS (Table 6.36). In addition, the maximum range of strong behavioural disturbance (using the 160 dB (rms) threshold) was modelled out to 140 m for CPT and 80 m for UHRS (impulsive noise sources) (Table 6.37). The disturbance ranges for non-impulsive noise sources ranged from 27 m to 9,101 m, with up to 47 animals potentially experiencing disturbance at the highest range (Table 6.38). The injury and disturbance ranges do not extend to the SAC (located 113.96 km away) and therefore animals are unlikely to experience significant disturbance within the site. Site-investigation surveys will therefore not affect areas important for breeding and pupping within the SAC, and therefore grey seal will remain a viable component of the site. Overall, including the implementation of designed in mitigation measures, site-investigation surveys are not predicted to prevent the population or distribution of grey seal within the site from being maintained. |
| | The distribution of qualifying species within the site are maintained | |

649. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of as a result of injury and disturbance due to site-investigation surveys during the construction and operation and maintenance phases of the Array alone.

Southern North Sea SAC

Harbour porpoise

Injury

650. An overview of potential auditory injury (PTS) due to elevated underwater noise during site-investigation surveys is described in paragraph 620 *et seq.* and is applicable to construction and operation and maintenance phase activities. As detailed in Table 6.34, the modelled PTS impact ranges were low for harbour porpoise for geophysical site investigation techniques. These ranged from 10 m (UHRS), 75 m (MBES and SSS), and 310 m (SBP). Based on these modelled injury ranges, no more than one harbour porpoise from the North Sea MU population would have the potential to experience PTS as a result of geophysical site-investigation survey equipment (Table 6.36).

651. As detailed in Table 6.35, the PTS impact range for harbour porpoise will not be exceeded for borehole drilling and vibrocoring, and therefore no animals will potentially be impacted as a result (Table 6.36). For CPT, potential PTS ranges were modelled out to a maximum of 45 m (Table 6.35), with up to one harbour porpoise potentially impacted (Table 6.36). The PTS ranges for any geophysical and geotechnical survey equipment will not overlap with the Southern North Sea SAC, which is a minimum of 129.86 km south-east from the site boundary.

652. Overall, since the risk of injury is assumed to be fully mitigated via designed in measures (Table 6.33) there is considered to be no residual risk of injury and therefore no population-level effects for harbour porpoise.

Behavioural disturbance

653. An overview of potential behavioural disturbance due to elevated underwater noise during site-investigation surveys is described in paragraph 628 *et seq.* and is applicable to construction and operation and maintenance phase activities.

654. For impulsive noise sources (UHRS, CPT) the underwater noise modelling adopted the NMFS (2005) thresholds of 140 dB re 1 µPa for mild disturbance and 160 dB re 1 µPa for strong disturbance. For non-impulsive noise sources (MBES, SSS, SBP, borehole, vibrocore) the underwater noise modelling used the NMFS (2005) threshold of 120 dB re 1 µPa.

655. For impulsive noise sources (UHRS and CPT) the strong behavioural disturbance ranges vary from 80 m during UHRS to 140 m during CPT for all species (Table 6.37). Qualitatively, up to four harbour porpoise may experience strong behavioural disturbance as a result of CPT and up to one due to UHRS (Table 6.38). Mild disturbance may occur within 565 m during UHRS to 1,330 m during CPT for all species. However, such low level disturbance could lead to mild disruptions of normal behaviours, but prolonged or sustained behavioural effects, including displacement are unlikely to occur.

656. The underwater noise modelling predicted that behavioural disturbance due to non-impulsive site-investigation survey equipment could occur within a range of between 27 m (borehole drilling) and up to 9,101 m (vibrocoring) for all species (Table 6.37). Potential disturbance ranges were 320 m, 375 m, and 1,340 m for SSS, MBES, and SBP, respectively (Table 6.37). Qualitatively, no more than one harbour porpoise is predicted to be disturbed during MBES, SSS and borehole drilling (Table 6.38). With the use of SBP, up to four harbour porpoise are at risk of experiencing disturbance. Due to relatively large disturbance ranges predicted for vibrocoring, based on conservative species-specific densities, up to 170 harbour porpoise could experience disturbance (Table 6.38). However, as described in paragraph 632, the numbers of animals potentially disturbed presented for vibrocore and other site-investigation surveys are likely to be an overestimate.

657. The behavioural disturbance ranges will not overlap with the Southern North Sea SAC, which lies 129.86 km south of the site boundary.

658. A study by van Beest *et al.* (2018) used fine-scale data from harbour porpoise equipped with high-resolution location and dive loggers when exposed to airgun pulses at ranges of 420 m to 690 m with sound level estimates of 135 dB re $1\mu Pa^2s$ to 147 dB re $1\mu Pa^2s$ (SEL). They showed different responses to sound exposure, with one individual displayed rapid and directed movements away from the exposure site whilst two individuals used shorter and shallower dives (compared to natural behaviour) immediately after exposure. This sound-induced movement typically lasted for eight hours or less, with an additional 24 hour recovery period until natural behaviour was resumed (van Beest *et al.* (2018)).

659. A recent study by Sarnocińska *et al.* (2020) indicated temporary displacement or change in harbour porpoise echolocation behaviour in response to a 3D seismic survey in the North Sea. No general displacement was detected from 15 km away from any seismic activity but decreases in echolocation signals were detected up to 8 to 12 km from the active airguns. Considering findings of other studies

(Dyndo *et al.*, 2015, Tougaard *et al.*, 2015), harbour porpoise disturbance ranges due to airgun sound are predicted to be smaller than to piling sound at the same energy. The reason for this is that the perceived loudness of the airgun pulses is predicted to be lower than for piling due to less energy at the higher frequencies where porpoise hearing is better (Sarnocińska *et al.*, 2020). Likewise, Thompson *et al.* (2013) used PAM and DAS to study changes in the occurrence of harbour porpoise across a 2,000 $km^2$ study area during a commercial 2D seismic survey in the North Sea. The study found acoustic detections decreased significantly during the survey period in the impact area compared with a control area, but this effect was small in relation to natural variation. Animals were typically detected again at affected sites within a few hours, and the level of response declined through the survey period (ten days) suggesting exposure led to some tolerance of the activity (Thompson *et al.*, 2013). Thompson *et al.* (2013) therefore suggested that prolonged seismic survey activity did not lead to broader-scale displacement into sub-optimal or higher risk habitat.

660. Overall, the effect of behavioural disturbance from site-investigation surveys is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). Whilst there may be minor effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects for the harbour porpoise feature of the Southern North Sea SAC.

Conclusion

661. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of injury and disturbance due to site-investigation surveys during the construction and operation and maintenance phases. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.40.

**Table 6.40: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Injury and Disturbance due to Site-Investigation Surveys (Including Geophysical Surveys) during the Construction and Operation and Maintenance Phases of the Array Alone**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site | Overall, site-investigation surveys in the construction and operation and maintenance phases of the Array are unlikely to lead to auditory injury or strong behavioural responses to harbour porpoise. The maximum injury range (in terms of PTS) estimated for harbour porpoise was 310 m using the $SPL_{pk}$ metric for SBP equipment. At this range, up to one animal may experience PTS (Table 6.36). In addition, the maximum range of strong behavioural disturbance (using the 160 dB (rms) threshold) was modelled out to 140 m for CPT and 80 m for UHRS (impulsive noise sources) (Table 6.37). The disturbance ranges for non-impulsive noise sources ranged from 27 m to 9,101 m, with up to 170 animals potentially experiencing disturbance at the highest range (Table 6.38). The injury and disturbance ranges do not extend to the SAC and therefore animals are unlikely to experience significant disturbance within the site. Site-investigation surveys will therefore not affect areas important for breeding and calving within the SAC, and therefore harbour porpoise will remain a viable component of the site. Overall, including the implementation of designed in mitigation measures, site-investigation surveys are not predicted to impact the population from being able to maintain itself as a viable component of the site over the long term. |
| | 2. There is no significant disturbance of the species | As noted in the row above, strong behavioural disturbance using the 160 dB (rms) threshold was modelled out to 140 m for CPT survey equipment. For non-impulsive sources, the disturbance ranged from 27 m to 9,101 m, with up to 170 animals potentially experiencing disturbance at the highest range (Table 6.38). Given that these ranges do not extend to the site (129.86 km away), it is anticipated that there will be no significant disturbance to the harbour porpoise feature of the site. |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for potential impact between this impact and the habitats and supporting processes of harbour porpoise. With respect to the availability of prey, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.3.4), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support harbour porpoise will not be adversely affected by this impact. |

662. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of site-investigation surveys during the construction and operation and maintenance phases of the Array alone.

Moray Firth SAC

Bottlenose dolphin

Injury

663. An overview of potential auditory injury due (PTS) to elevated underwater noise during site-investigation surveys is described in paragraph 620 *et seq.* and is applicable to construction and operation and maintenance phase activities. As detailed in Table 6.34, the modelled PTS impact ranges were low for bottlenose dolphin for geophysical site investigation techniques. These ranged between 65 m for MBES and 75 m for SSS and SBP. The threshold was not exceeded for UHRS. Based on these modelled injury ranges, no more than one bottlenose dolphin from the Coastal East Scotland MU population would have the potential to experience PTS as a result of geophysical site-investigation survey equipment (Table 6.36).

664. As detailed in Table 6.35, the PTS impact range for bottlenose dolphin will not be exceeded for any geotechnical site investigation survey techniques, and therefore no animals will potentially be impacted as a result (Table 6.36). The PTS ranges for any geophysical and geotechnical survey equipment will not overlap with the Moray Firth SAC, which is a minimum of 175.86 km north-west from the site boundary.

665. Overall, since the risk of injury is assumed to be fully mitigated via designed in measures (Table 6.33) there is considered to be no residual risk of injury and therefore no population-level effects for bottlenose dolphin.

Behavioural disturbance

666. An overview of potential behavioural disturbance due to elevated underwater noise during site-investigation surveys is described in paragraph 628 *et seq.* and is applicable to construction and operation and maintenance phase activities.

667. For impulsive noise sources (UHRS, CPT) the underwater noise modelling adopted the NMFS (2005) thresholds of 140 dB re 1 µPa for mild disturbance and 160 dB re 1 µPa for strong disturbance. For non-impulsive noise sources (MBES, SSS, SBP, borehole, vibrocore) the underwater noise modelling used the NMFS (2005) threshold of 120 dB re 1 µPa.

668. For impulsive noise sources (UHRS and CPT) the strong behavioural disturbance ranges vary from 80 m during UHRS to 140 m during CPT for all species (Table 6.37). Qualitatively, up to one bottlenose dolphin may experience strong behavioural disturbance as a result of UHRS and none for CPT (Table 6.38). Mild disturbance may occur up to 565 m during UHRS and up to 1,330 m during CPT for all species. Such low level disturbance could lead to mild disruptions of normal behaviours, but prolonged or sustained behavioural effects, including displacement are unlikely to occur.

669. The underwater noise modelling predicted that behavioural disturbance due to non-impulsive site-investigation survey equipment could occur within a range of between 27 m (borehole drilling) and up to 9,101 m (vibrocoring) for all species (Table 6.37). Potential disturbance ranges were 320 m, 375 m, and 1,340 m for SSS, MBES, and SBP, respectively (Table 6.37). Qualitatively, no more than one bottlenose dolphin is predicted to be disturbed during MBES, SBP, SSS and borehole drilling (Table 6.38). Even given the relatively large disturbance ranges predicted for vibrocoring, based on conservative bottlenose dolphin densities, up to one bottlenose dolphin could experience disturbance (Table 6.38). However, as described in paragraph 632, the numbers of animals potentially disturbed presented for vibrocore and other site-investigation surveys are likely to be an overestimate.

670. The behavioural disturbance ranges presented in Table 6.37 will not overlap with the Moray Firth SAC, which lies 175.86 km of the site boundary.

Conclusion

671. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of site-investigation surveys during the construction and operation and maintenance phases. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.41.

**Table 6.41: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Injury and Disturbance due to Site-Investigation Surveys (Including Geophysical Surveys) during the Construction and Operation and Maintenance Phases of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site | Overall, site-investigation surveys in the construction and operation and maintenance phases of the Array are unlikely to lead to injury or strong behavioural responses to bottlenose dolphin. The maximum injury (in terms of PTS) range estimated for harbour porpoise was 75 m using the $SPL_{pk}$ metric for SBP and SSS equipment. At this range, up to one animal may experience PTS (Table 6.36). In addition, the maximum range of strong behavioural disturbance (using the 160 dB (rms) threshold) was modelled out to 140 m for CPT and 80 m for UHRS (impulsive noise sources) (Table 6.37). The disturbance ranges for non-impulsive noise sources ranged from 27 m to 9,101 m, with up to one animal potentially experiencing disturbance at the highest range (Table 6.38). The injury and disturbance ranges do not extend to the SAC and therefore animals are unlikely to experience significant disturbance within the site. Site-investigation surveys will therefore not affect areas important for breeding and calving within the SAC, and therefore bottlenose dolphin will remain a viable component of the site. Overall, including the implementation of designed in mitigation measures, site-investigation surveys are not predicted to impact the population from being able to maintain itself as a viable component of the site over the long term. |
| | 2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance | As noted in the row above, strong behavioural disturbance using the 160 dB (rms) threshold was modelled out to 140 m for CPT survey equipment. For non-impulsive sources, the disturbance ranged from 27 m to 9,101 m, with up to one animal potentially experiencing disturbance at the highest range (Table 6.38). Given that these ranges do not extend to the site (175.86 km away), it is anticipated that there will be no significant disturbance to the bottlenose dolphin feature of the site. |
| | 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained | There is no pathway for potential impact between this impact and the habitats and supporting processes of bottlenose dolphin. With respect to the availability of prey, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.3.4), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support bottlenose dolphin will not be adversely affected by this impact. |

672. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of site-investigation surveys during the construction and operation and maintenance phases of the Array alone.

### 6.3.4. CHANGES IN PREY AVAILABILITY

673. The LSE[2] assessment during the HRA Stage One process identified that LSE[2] could not be ruled out for changes in prey availability due to underwater noise from piling and UXO clearance during the construction phase of the Array alone. This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

674. The MDS and designed in measures considered for the assessment of changes in prey availability are shown in Table 6.42 and Table 6.43 respectively

**Table 6.42: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Changes in Prey Availability during the Construction Phase**

| Project Phase | MDS | Justification |
|---|---|---|
| Construction | **Piling**<br><br>Wind turbines:<br>• up to 265 14 MW semi-submersible floating wind turbine foundations with up to 6 anchors per foundation and one 4.5 m diameter pile per anchor (1,590 piles);<br>• absolute maximum scenario is for 100% of piles to be driven piles;<br>• maximum hammer energy of up to 3,000 kJ;<br>• up to 2 vessels piling concurrently at floating wind turbine anchors;<br>• minimum 950 m and maximum 30 km distance between concurrent piling events;<br>• up to 8 hours maximum piling per pile, therefore 3 piles installed over 24 hours;<br>• total duration of piling of 12,720 hours over 530 days; and<br>• total piling phase at floating wind turbine anchors of 63 months over a period of 7 years (within the 8 years construction phase).<br><br>Offshore Substation Platforms (OSPs):<br>• up to 3 large and 12 small OSP jacket foundations with up to 12 and 6 legs per foundation, respectively; 24 x 4.5 m (large) and 12 x 3.0 m (small) diameter piles per leg (total of 216 piles);<br>• maximum hammer energy of up to 4,400 kJ;<br>• only 1 vessel piling at any one time at OSP locations;<br>• up to 8 hours maximum piling per pile, therefore 3 piles installed over 24 hours;<br>• total duration of piling of 1,728 hours over 72 days;<br>• total piling phase at OSP foundations of 72 months over a period of 8 years; and<br>• there is a potential for 2 vessels piling concurrently at either 2 wind turbine anchor locations or 1 wind turbine anchor and 1 OSP foundation. There may be up to 602 days in which piling may occur within the piling phase at floating wind turbine anchors and OSPs.<br><br>**UXO Clearance**<br>• clearance of up to 15 UXOs within the site boundary;<br>• maximum UXO size of up to 698 kg Net Explosive Quantity (NEQ), realistic maximum weight of 227 kg NEQ;<br>• UXO clearance campaign will involve the use of up to 2 vessels on site at any one time with up to 4 return trips;<br>• intention for clearance of all UXOs using low order techniques (subsonic combustion) with a single donor charge of up to 0.25 kg NEQ for each clearance event;<br>• up to 0.5 kg NEQ clearance shot for neutralisation of residual explosive material at each location;<br>• up to 2 detonations within 24 hours;<br>• total duration of UXO clearance campaign 8 days excluding any time lost due to weather conditions; and<br>• clearance during daylight hours only. | The MDS for this potential impact is as presented in Table 5.3 for the assessment of underwater noise generated during piling and UXO clearance in the construction phase. This potential impact has been informed by the conclusions of the fish and shellfish ecology assessment (volume 2, chapter 9 of the Array EIA Report) which will result in the greatest potential impact on prey availability.<br><br>The largest hammer energy and the maximum spacing between two concurrent piling vessels could lead to the largest area of ensonification at any one time. Minimum spacing between concurrent piling represents the highest risk of injury to animals. Note that concurrent piling for wind turbine anchors has been assumed as the MDS, but it may occur as a combination of wind turbine anchors and OSP foundations. The maximum number of days when piling occurs will result in the greatest temporal impact. In total, a maximum of two piling vessels will be piling at any one time.<br><br>Maximum number and maximum size of UXOs encountered within the site boundary is based on the UXO Hazard Assessment undertaken for the Array. Donor charge is the maximum required to initiate low order detonation. Assumption of a clearance shot of up to 0.5 kg at all locations, although noting that this may not always be required. |

**Table 6.43: Designed In Measures Considered for the Assessment of Potential Impacts to Annex II Marine Mammals to Changes in Prey Availability during the Construction Phase**

| Designed In Measures | Justification | How the Designed In Measure will be Secured |
|---|---|---|
| Implementation of soft start measures for UXO clearance using a sequence of small explosive charges detonated over set time intervals. | During piling operations, soft starts will be used. This will involve the implementation of lower hammer energies at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels. This measure will reduce the risk of injury to prey fish species in the immediate vicinity of piling operations, either by allowing some species/individuals to flee the area before noise levels reach a level at which injury may occur, and/or by limiting the total amount of noise energy entering the environment. | UXO clearance will be subject to a separate Marine Licence application and EPS Licence as appropriate. Mitigation, including, implementation of low order disposal will be secured through the relevant Marine Licence and EPS licence. |
| UXO clearance using low order disposal techniques where technically feasible. | Low order techniques will be adopted wherever practicable (e.g. deflagration and clearance shots). However, as noted in paragraph 173, there is a small risk that low order could unintentionally arise in a high order detonation and therefore this scenario has also been considered in the assessment. This measure will reduce the noise levels and the potential for injury to prey fish species in the vicinity of UXO clearance operations. | UXO clearance will be subject to a separate Marine Licence application and EPS Licence as appropriate. Mitigation, including, implementation of low order disposal will be secured through the relevant Marine Licence and EPS licence. |

### Information to inform the assessment

Overview of potential changes to prey availability

675. As concluded in the Array HRA Stage One LSE[2] Screening Report (Array RIAA Part 1, appendix 1A) Annex II grey seal, harbour porpoise, and bottlenose dolphin are likely to be present within the Array marine mammal study area and may forage within the area. Effects on prey fish populations across all phases of the Array are likely to be temporary, of a short duration, localised and not significant. The widest ranging effect will be from increased underwater noise during the construction phase (mainly due to piling) and is unlikely to be significant in other phases (Array RIAA Part 1, appendix 1A). However, as impacts to prey species have been assessed as part of the underwater noise modelling assessment that has been undertaken for the EIA, this potential impact was included for the construction phase as a precaution for the Annex II marine mammal features of their respective SACs.

676. The underwater noise modelling for all fish hearing groups (i.e. Groups 1 to 4, as opposed to just the results of Groups 1 and 2 presented in section 5.3.1 for the Annex II diadromous fish assessment) was summarised and assessed in volume 2, chapter 9 of the Array EIA Report. For the $SPL_{pk}$ metric associated with the MDS presented in Table 6.42, the maximum recoverable injury range is estimated at 138 m to 228 m from the piling location. The potential for mortality or mortal injury to fish eggs would also occur at distances of up to 228 m. However, this was considered to be highly conservative due to the implementation of soft starts during piling operations which may allow some fish to move away from the areas of highest noise levels, before the received noise reaches a level that would cause an injury (Table 6.43). As such, the maximum injury ranges predicted for soft start initiation (i.e. of the order of tens of metres) are likely to be more realistic. For the $SEL_{cum}$ metric, underwater noise modelling showed that TTS, for the various fish hearing groups could occur out to a maximum distance of 4,161 m for single piling scenario at 4,000 kJ. The potential onset of behavioural effects (such as elicitation of a startle response, disruption of feeding, or avoidance of an area) may occur to ranges of low tens of kilometres. However, responses will differ depending on the sensitivity of the species and the presence/absence of a swim bladder (Popper *et al.*, 2014). Underwater noise only has the potential to impact prey species over a relatively small area in terms of the regional marine mammal study area as a whole. As presented in volume 2, chapter 9 of the Array EIA Report, this potential impact was assessed as being of negligible to minor adverse significance for all fish and shellfish species.

677. With respect to indirect effects on marine mammals, no additional indirect effects other than those assessed for injury and disturbance to marine mammals as a result of elevated underwater noise during piling and UXO clearance have been predicted. This is because if prey were to be disturbed from an area as a result of underwater noise from these activities, it is assumed that marine mammals would be disturbed from the same or greater area. Thus, any changes to the distribution of prey resources would not affect marine mammals as they would already be disturbed from the same (or larger) area. Whilst there may be certain prey species that comprise the main part of their diet, all Annex II marine mammals in this assessment are generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging in nature and have a generalist feeding strategy, with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

678. The key prey species for marine mammals include sandeels, gadoids (including cod, haddock, Norway pout *Trisopterus esmarkii,* and whiting), clupeids (herring, mackerel *Scomber scombrus,* and sprat), flatfish (plaice, lemon sole *Microstomus kitt,* and Pleuronectiformes) (see volume 3, appendix 10.2 of the Array EIA Report for further detail on marine mammal feeding ecology). These prey species have been identified as being of regional importance within the fish and shellfish ecology study area, except for sandeel which is deemed to be of national importance (see volume 2, chapter 9 of the Array EIA Report). The site boundary overlaps with spawning grounds for cod, lemon sole, mackerel, Norway pout, plaice, sandeels, and whiting based on Coull *et al.* (1998) and Ellis *et al.* (2012). For herring, no high intensity spawning grounds identified by Coull *et al.* (1998) directly overlap with the Array marine mammal study area (noting low intensity grounds overlap). Outputs of modelling conducted by Langton *et al.* (2021) show that the whole Array marine mammal study area has extremely low probability of sandeel presence, with areas where predicted density is high closer to the coasts or towards the Firth of Forth.

679. As the impact of underwater noise affecting fish and shellfish species was assessed as neglgilbe to minor adverse significance within volume 2, chapter 9 of the Array EIA Report, changes in prey availability is not predicted to affect the integrity of the SACs or have population-level effects upon Annex II marine mammals.

### Construction phase

Berwickshire and North Northumberland Coast SAC

Grey seal

680. The results of the underwater noise modelling suggest that prey species may be impacted due to underwater noise up to tens of kilometres from the site boundary (paragraph 675 *et seq.*). Therefore, underwater noise only has the potential to impact prey species over a relatively small area in terms of the regional marine mammal study area as a whole.

681. As detailed in paragraphs 410 and 411, grey seals forage offshore out to and over 100 km and prey on a range of fish, such as flatfish, sandeels, and gadoids (Damseaux *et al.*, 2021, Gosch, 2017, Hammond *et al.*, 2005). Given that the impacts of underwater noise on prey species will be highly localised (in terms of injury) and within tens of kilometres for behavioural disturbance, only a small area will be affected when

compared to available foraging habitat for grey seals in the regional marine mammal study area. There may be an energetic cost associated with increased travelling if prey patches are disturbed, however, grey seal is not considered to be particularly vulnerable to this, as foraging trips tend to be wide-ranging (e.g. up to and over 100 km (SCOS, 2023)). There is also evidence that grey seal in Scotland tend to stay within 20 km of their breeding colonies during the breeding season (*pers. comm.* with NatureScot). The availability of wider suitable habitat across the regional marine mammal study area suggest that individuals may move to alternative foraging grounds without health impairment. It is expected that grey seal population would be able to tolerate the effect without any potential impact on reproduction and survival rates.

682. As outlined in paragraph 675 *et seq.,* no significant adverse effects were predicted to occur to fish and shellfish species during the construction phase of the Array (volume 2, chapter 9 of the Array EIA Report)

683. Therefore, this potential impact is not predicted to result in adverse effects (i.e. disruption to foraging) for the grey seal feature of this SAC.

Conclusion

684. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of changes in prey availability during the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in in section 6.2.1) are discussed in turn below in Table 6.44.

**Table 6.44: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Changes in Prey Availability during the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for impact between changes in prey availability and the extent, distribution, structure and function of habitats and supporting processes of grey seal. Therefore, changes in prey availability will not prevent these conservation objectives from being maintained. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | Impacts to prey species are predicted to be insignificant, and grey seal expected to adapt and recover quickly to any changes in prey availability. As such there is a negligible risk of disruption of foraging activities of grey seal. Therefore, changes in prey availability associated with underwater noise in the construction phase of the Array will not affect the survivability and reproductive potential of grey seal within the SAC. Similarly, changes in prey availability will not significantly disturb the species. As such, and with additional consideration of the designed in measures, changes in prey availability are not predicted to prevent the population or distribution of grey seal within the site from being maintained. |
| | The distribution of qualifying species within the site are maintained | |

685. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of changes in prey availability in the construction phase of the Array alone.

Southern North Sea SAC

Harbour porpoise

686. The results of the underwater noise modelling suggest that prey species may be impacted due to underwater noise up to tens of kilometres from the site boundary (paragraph 675 *et seq.*). Given that the impacts of underwater noise on prey species will be highly localised (in terms of injury) and within tens of kilometres for behavioural disturbance, underwater noise only has the potential to impact prey species over a relatively small area in terms of the regional marine mammal study area as a whole. As detailed in paragraph 420, harbour porpoise has a high metabolic rate. Therefore, there may be an energetic cost associated with disruption to foraging and this species may be particularly vulnerable to this impact. However, harbour porpoises have a widespread distribution throughout the North Sea as a whole, and individuals have been documented either switching to different prey species depending on the prey availability (Santos *et al.*, 2003), or moving relatively large distances on a daily basis (Nielsen *et al.*, 2013). Based on the findings of Benhemma-Le Gall *et al.* (2021), it can be anticipated that harbour porpoise can compensate for any resulting loss in energy intake by increasing foraging activities beyond potentially affected areas. The availability of wider suitable habitat across the regional marine mammal study area suggest that individuals may move to alternative foraging grounds without health impairment.

687. As outlined in paragraph 675 *et seq.,* no significant adverse effects were predicted to occur to fish and shellfish species during the construction phase of the Array (volume 2, chapter 9 of the Array EIA Report)

688. Therefore, this potential impact is not predicted to result in adverse effects (i.e. disruption to foraging) for the harbour porpoise feature of this SAC.

Conclusion

689. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of changes in prey availability during the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.45.

**Table 6.45: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Changes in Prey Availability during the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site<br>2. There is no significant disturbance of the species | Impacts to prey species are predicted to be insignificant, and harbour porpoise are expected to adapt and recover quickly to any changes in prey availability. As such there is a negligible risk of disruption of foraging activities of harbour porpoise. Therefore, changes in prey availability associated with underwater noise in the construction phase of the Array will not affect the survivability and reproductive potential of harbour porpoise within the SAC and they will remain a viable component of the site. Similarly, changes in prey availability will not significantly disturb the species. As such changes in prey availability are not predicted to impact the population from being able to maintain itself as a viable component of the site or cause significant disturbance to harbour porpoise. |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no impact pathway between changes in prey availability and the habitats and supporting processes of harbour porpoise. Therefore, this potential impact will not prevent this conservation objective from being maintained. |

690. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of changes in prey availability in the construction phase of the Array alone.

Moray Firth SAC

Bottlenose dolphin

691. The results of the underwater noise modelling suggest that prey species may be impacted due to underwater noise up to tens of kilometres from the site boundary (paragraph 675 *et seq.*). Given that the impacts of underwater noise on prey species will be highly localised (in terms of injury) and within tens of kilometres for behavioural disturbance, underwater noise only has the potential to impact prey species over a relatively small area in terms of the regional marine mammal study area as a whole. In addition, the bottlenose dolphin feature of the Moray Firth SAC are typically coastal, and the site boundary (approximately 80 km offshore) is not likely to represent a key foraging ground for this population.

692. The habitat use of bottlenose dolphin varies greatly, even within a population, and generally the distribution of this species is influenced by factors such as tidal state, weather conditions, resource availability, life cycle stage, or season (Hastie *et al.*, 2004). Typical prey items for bottlenose dolphin in Scottish waters include Atlantic salmon, cod, haddock, saithe, and whiting (Santos *et al.*, 2001), therefore, they have been considered to be generalist feeders.

693. There is a seasonal pattern of bottlenose dolphin movement from the Tay estuary and adjacent waters to the Moray Firth SAC in the early summer months, and from the Moray Firth SAC to the Tay estuary and adjacent waters in late summer (Arso Civil *et al.*, 2021). This movement is anticipated to be driven by environmental and biological factors (Arso Civil *et al.*, 2021). Studies by Wilson *et al.* (1997) and Hastie *et al.* (2004) reported that these two areas share topographically distinct characteristics with increased observations of dolphins foraging. Seasonal changes in prey presence over variable temporal scales throughout the year may therefore enable bottlenose dolphins to exploit these areas within their range at different times.

694. As outlined in paragraph 675 *et seq.,* no significant adverse effects were predicted to occur to fish and shellfish species during the construction phase of the Array (volume 2, chapter 9 of the Array EIA Report)

695. Therefore, this potential impact is not predicted to result in adverse effects (i.e. disruption to foraging) for the bottlenose dolphin feature of this SAC.

Conclusion

696. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of changes in prey availability during the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.46.

**Table 6.46: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Changes in Prey Availability during the Construction Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site<br>2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance | Impacts to prey species are predicted to be not significant, and therefore bottlenose dolphin are expected to adapt and recover quickly to any changes in prey availability given their mobile nature and generalist feeding strategy. As such there is a negligible risk of disruption of foraging activities of bottlenose dolphin. Therefore, changes in prey availability associated with underwater noise in the construction phase of the Array will not affect the survivability and reproductive potential of bottlenose dolphin within the SAC and they will remain a viable component of the site. Similarly, changes in prey availability will not significantly disturb the species. As such, and with additional consideration of the designed in measures, changes in prey availability are not predicted to impact the population from being able to maintain itself as a viable component of the site or cause significant disturbance to bottlenose dolphin. |
| | 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained | There is no pathway for potential impact between changes in prey availability and the habitats and supporting processes of bottlenose dolphin. Therefore, this potential impact will not prevent this conservation objective from being maintained. |

697. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of changes in prey availability in the construction phase of the Array alone.

### 6.3.5. ENTANGLEMENT

698. The LSE[2] assessment during the HRA Stage One process identified that during the operation and maintenance phase, LSE[2] could not be ruled out for entanglement. This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

699. The MDS and secondary mitigation measures considered for the assessment of entanglement are shown in Table 6.47 and Table 6.48, respectively.

**Table 6.47: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Entanglement during the Operation and Maintenance Phase**

| Project Phase | MDS | Justification |
|---|---|---|
| Operation and maintenance | Up to 265 floating wind turbines; spatial extent of the site boundary of 858 km$^2$.<br><br>Inter-array cables:<br>• up to 1,261 km of inter-array cables with a minimum diameter of 100 mm and a maximum external diameter of 300 mm; and<br>• up to 116 km of inter-array cables will be dynamic in the water column.<br><br>Mooring lines:<br>• up to 1,590 catenary mooring lines;<br>• maximum line length of up to 750 m (measured from the connection at the sea surface to the anchor located at the deepest water depth);<br>• maximum mooring radius of up to 700 m (measured from the anchor to the floater when located at a neutral central point within the excursion limit);<br>• 200 m per mooring line will be dynamic in water column during the operation and maintenance phase with potential increases to 700 m during storms; and<br>• the mooring line attachment to the foundation will be between 15 m above surface to 20 m below sea level.<br><br>Operation and maintenance phase of up to 35 years.<br><br>Routine inspections of the inter-array cables and mooring lines will take place every 6 months during first 2 years and then annually, with removal of marine debris as required. | The maximum scale, type and dimensions of the mooring lines and inter-array cables in the water column represent the maximum potential for entanglement. |

**Table 6.48: Designed In Measures Considered for the Assessment of Potential Impacts to Annex II Marine Mammals to Entanglement during the Operation and Maintenance Phase**

| Designed In Mitigation Measure | Justification | How the Designed In Mitigation Measure will be Secured |
|---|---|---|
| Routine inspections of the inter-array cables and mooring lines. | Mooring lines and dynamic inter-array cables in the water column will undergo regular inspections during the operation and maintenance phase with inspection frequency more frequent initially for the first two years and then decreasing to an annual schedule. The removal of marine debris from mooring lines and inter array cables will be undertaken as necessary following monitoring and further relevant action taken if required, based on findings from the inspections. The removal of debris from mooring lines and cables further reduces the likelihood of secondary entanglement. | Secured in the Section 36 Consent and/or Marine Licence via the requirement for an Operation and Maintenance Programme (OMP) which will be submitted to MD-LOT for approval post-consent. |

Information to inform the assessment

Overview of entanglement

700. To provide stability and the fixed positioning of floating wind turbines within the Array, effective mooring systems will be implemented. Additionally, a connection to dynamic inter-array cables will facilitate interlinking between individual wind turbines.

701. There are concerns regarding the hazards that mooring lines and dynamic cables may pose to marine mammals, which could inadvertently become entangled or entrapped (MD-LOT, 2023). The entanglement risk can be categorised into two types: primary and secondary (SEER, 2022). Primary entanglement refers to the direct entanglement of marine life with mooring lines or dynamic cables. Secondary entanglement occurs when marine life becomes entangled with marine debris, such as derelict fishing gear, that has become snagged on a mooring line or dynamic cable (SEER, 2022). According to Benjamins *et al.* (2014), the entanglement risk is contingent upon various physical and biological parameters. Physical parameters, integral to the wind farm design, encompass mooring tension characteristics, cable/mooring line diameter, swept volume and curvature. In parallel, biological parameters include body size, the ability of animals to detect moorings, body flexibility and general feeding modes.

702. As outlined in the MDS (Table 6.47), the Array will have up to 116 km of dynamic inter-array cables within the water column. Each wind turbine will be equipped with a mooring system, which introduces the additional potential for entanglement, with up to 1,590 mooring lines. The Project Description for the Array considers various mooring line design options for semi-submersible floating wind turbines, including full chain catenary, semi-taut and taut, both incorporating a top fibre rope section (nylon or polyester) and a bottom chain section.

703. According to Benjamins *et al.* (2014), tension characteristics in moorings significantly affect entanglement risk, with taut moorings under high tension being less likely to cause entanglement than flexible ones under low tension. The potential impact of dynamic moorings can be assessed by the concept of swept volumes, as it considers the volume of the water column occupied by mooring lines under energetic conditions (Benjamins *et al.*, 2014). A useful physical parameter in the assessment of entanglement is also curvature, as it assesses the bending of mooring lines, with taut configurations exhibiting smaller curvatures compared to catenary configurations (Benjamins *et al.*, 2014). Harnois *et al.* (2015) found that the catenary moorings with chains configuration shows the highest curvature values.

704. Benjamins *et al.* (2014) findings indicate a greater risk of entanglement to marine mammals with catenary moorings, particularly those containing nylon. Across all potential mooring line types considered for the Array, catenary moorings represent the MDS for entanglement risk. It can be anticipated that, especially for catenary mooring type, there will be some horizontal movement of the floating wind turbine and therefore the mooring line may experience stretching (representing the maximum length in the water column) or slackness (representing the maximum length resting on the seabed). To address this, clump weights may be strategically placed around the touchdown point to mitigate the length of the mooring line between the anchor and the wind turbine.

705. While Harnois *et al.* (2015) suggest that certain features of mooring systems may influence entanglement risk, the study also concluded that the absolute risk of primary entanglement is low regardless of mooring configuration. Garavelli (2020) suggested that all mooring configurations (catenary/taut) have too much tension to create a loop that could entangle a whale. This has been corroborated by SEER (2022), as the study also concluded that the risk of primary entanglement at floating offshore wind farms is very low due to the weight of the cable systems. The potential for heavy mooring gear combined with relatively taut mooring lines to entangle whales has been shown to be negligible (Wursig *et al.*, 2002) and Marine Renewable Energy (MRE) device moorings are unlikely to pose a major threat (Benjamins *et al.*, 2014). Statoil (2015) stated for mooring lines at the Hywind Scotland Pilot Park Project, it was a design requirement that no line should ever go into slack, even in extreme weather conditions, and it was considered effectively impossible for entanglement on a marine mammal to occur. For inter-array cables in the water column cables have a very high bending stiffness and therefore the cable cannot bend around

a marine mammal (Statoil, 2015). Therefore, there is a very low risk that primary entanglement can actually occur.

706. Research on the risk to marine mammals has focussed on injury or mortality by entanglement of fishing gear (e.g. nets of slack lines) or submarine telecommunication cables, however these have loose ends or loops that could ensnare animals (Benjamins *et al.*, 2014, Moore *et al.*, 2006) and therefore mooring lines/cables from floating wind turbines are not comparable and has not been considered a significant concern (Copping *et al.*, 2020). Evidence of entanglement of marine animals with MRE mooring lines and cables has not been observed to date (Isaacman *et al.*, 2011, ORJIP Ocean Energy, 2022, Sparling *et al.*, 2013) and even entanglement with offshore aquaculture is rare (Fujita *et al.*, 2023), but it is important to consider absence of evidence is not evidence of absence of risk. However, there is a risk of entanglement in anthropogenic debris caught in mooring lines/cables (Clavelle *et al.*, 2019) (secondary entanglement).

707. The Array will use fibre rope diameters ranging from 110 mm to 300 mm and chain diameters between 76 mm to 175 mm. Fishing gear, which pose the greatest entanglement risk to marine species, were reported to fall between 1 mm to 9.5 mm in diameter (Knowlton *et al.*, 2016, Wilcox *et al.*, 2015). Thus, marine mammals are more likely to be at risk from secondary entanglement through interactions with fishing gears than through direct entanglement with the large, thick mooring and cable components.

708. Lost fishing gear is made of synthetic materials, including nylon, polyethylene, and polypropylene, that resist natural biodegradation and can endure in the marine environment for extended periods, promoting the phenomenon known as 'ghost fishing' (Stelfox *et al.*, 2016). Ghost fishing occurs when lost or discarded gear continues to catch wildlife from various taxa, including marine mammals. Indirect entanglement in anthropogenic debris caught on mooring lines and inter-array cables, e.g. secondary entanglement, poses the risk of direct injury and is anticipated to result in significant fitness reduction for the affected marine mammals though tissue damage, infection, and mobility restrictions that prevent foraging or migration (Garavelli, 2020, Van Der Hoop *et al.*, 2016). However, the quantification of the actual amount of abandoned, lost, or discarded fishing gear and other anthropogenic debris poses significant challenges due to its elusive nature.

709. As a part of the designed in measures (Table 6.48), mooring lines and dynamic inter-array cables will undergo regular inspections during the operation and maintenance phase. The inspection frequency for mooring lines and dynamic inter-array cables is anticipated to be more frequent initially (e.g. years 1 and 2), and likely to decline in frequency after this, following a risk based approach. Any inspected or detected debris on the floating lines and cables will be recovered based on a risk assessment which considers impact on environment including risk to marine mammal, risk to asset integrity, and health & safety. In addition, Ossian OWFL will consider new technologies for monitoring of mooring lines/snagged gear and will agree the approach to monitoring of mooring lines and associated removal of gear with NatureScot and MD-LOT prior to the operation and maintenance phase. As such, the removal of debris from mooring lines and cables further reduces the likelihood of secondary entanglement.

710. Finally, the risk of entanglement will be highly localised around the cables and mooring lines themselves and is not a wide-ranging impact such as those associated with elevated underwater noise.

<u>Sensitivity of Annex II marine mammals to entanglement</u>

711. In line with the approach applied in Benjamins *et al.* (2014), for the purpose of assessing marine mammal sensitivity to primary entanglement, the Annex II marine mammals considered in this Part of the RIAA were classified into broad groups based on taxonomic relationship as well as body size:

- odontocetes – harbour porpoise and bottlenose dolphin; and
- pinnipeds – grey seal.

712. Due to the infancy of the floating offshore wind farm industry there is a paucity of empirical evidence for secondary entanglement associated with floating offshore wind farms components (as discussed in paragraph 704), sensitivity to secondary entanglement has been assessed based on potential entanglement with lost or abandoned fishing gear (mostly nets, lines) that are most likely to be caught on the Array infrastructure. Since the impacts to marine mammals from entanglement in free floating fishing gear in the water column will be similar to entanglement in fishing gear caught on Array infrastructure, sensitivity to free floating fishing gear entanglement is considered to be a suitable proxy for the purposes of the assessment.

713. When considering the size of marine animals, mooring lines and cables may pose a reduced risk to smaller animals compared to larger ones simply because smaller animals ‘cannot physically become entangled’ (Benjamins *et al.*, 2014). Consequently, odontocetes as well as pinnipeds, face a lower risk of primary entanglement with mooring lines and inter-array cables compared to larger mysticetes.

714. In terms of flexibility, marine mammals exhibit variations in the degree to which they flex their bodies while swimming. Benjamins *et al.* (2014) made an assumption that animals with greater flexibility would be able to avoid entanglement more easily compared to those with more rigid bodies. The study assigned a consistent entanglement risk based on body flexibility for odontocetes. Pinnipeds, presumed to be relatively flexible, were consequently assigned a lower score for the risk of entanglement when compared to odontocetes and mysticetes (Benjamins *et al.*, 2014). As discussed in paragraph 705, it is highly unlikely that the mooring cables will be flexible enough to loop around passing marine mammals.

715. Due to the size of mooring lines and inter-array cables considered for the Array (see paragraph 707), they are detectable at considerable distances for echolocating odontocetes (such as harbour porpoise or bottlenose dolphin). Various mooring components are likely to influence audibility, with chain, for instance, being inherently noisier than fibre rope due to metal-on-metal movement and a larger surface area that can generate turbulence (Benjamins *et al.*, 2014). The smoothness of mooring elements surface will also impact the amount of turbulence produced, which is likely to be detectable by pinnipeds (Benjamins *et al.*, 2014). Nevertheless, detectability at a distance may be altered under adverse conditions such as storms or turbid waters, regardless of the sensory modality used or the extent of device motion. Benjamins *et al.* (2014) assessment of the entanglement risk across marine mammal groups, based on their ability to detect moorings, revealed that odontocetes who possess echolocation are more likely to detect mooring components at larger distances than pinnipeds which rely on passive acoustic detection or pressure wave detection. Pinnipeds however possess acute mechanosensitivity through their vibrissae or whiskers (Dehnhardt *et al.*, 2001, Hanke *et al.*, 2013) which may allow them to detect wakes formed downstream of a mooring or cable.

716. Foraging behaviour appears to be an important risk factor contributing to entanglement in fishing gears. Entanglements in ropes often occur as the rope wraps around animals' extremities or passes through their mouths, particularly during foraging activities (Benjamins *et al.*, 2014). Mysticetes are at a higher risk of entanglement when lunge feeding as opposed to filter feeding (Benjamins *et al.*, 2014), noting that studies have been based upon entanglement in fishing gear (Knowlton *et al.*, 2020), rather than mooring lines. The substantial thickness of mooring lines and inter-array cables associated with the Array, in comparison to the ropes used in fishing gears, may largely prevent such entanglements except in very specific cases (Benjamins *et al.*, 2014). Considering the mode of foraging alone, odontocetes and pinnipeds are assessed to be at a low risk of primary entanglement.

717. It must be noted that it is considered that marine mammals are highly unlikely to get entangled in the first place, given their advanced hearing and echolocation which would allow them to detect any noise from cables (such as ‘bangs’, ‘creaks’, ‘rattle’, ‘snapping’ or ‘pinging’) as described in Burns *et al.* (2022) and Liu (1973). Statoil (2015) assessed the sensitivity of marine mammal entanglement as low, given the risk of entanglement is considered highly unlikely. Furthermore, the evidence base for sensitivity is largely based off fishing gear or submarine telecommunications cables and therefore it is unlikely that the design of cables (see paragraphs 705 to 706) will physically allow primary entanglement of marine mammals to an extent that would entrap them and cause drowning. Thus, on the basis that primary entanglement is considered highly unlikely and the lack of any evidence for entanglement from MRE, there is considered to be some resilience and survivability largely due to avoidance behaviour of MRE structures.

718. The primary source of small cetacean bycatch is thought to be gillnets (Read *et al.*, 2006). One hypothesis explaining cetacean entanglement in gillnets suggests that these animals may either be incapable of detecting the nets due to low target strength or may detect the nets too late to avoid entanglement (Mackay,

2011). Limited information is available regarding how odontocete cetaceans utilise echolocation in the wild and the ecological as well as behavioural contexts in which the echolocation is used (Mackay, 2011). Bottlenose dolphin, for example, has been observed to use echolocation sparingly in the wild, predominantly relying on passive listening to detect prey (Gannon *et al.*, 2005). In contrast, free-ranging harbour porpoise has been documented to echolocate frequently (Akamatsu *et al.*, 2007).

719. Cox *et al.* (2004) reported that harbour porpoise are often found in the vicinity of commercial gillnets more frequently than actual entanglement events occur. Kastelein *et al.* (1995) examined the circumstances in which three captive harbour porpoises reacted to gillnets in a pool. The initial encounters of the animals with standing gillnets resulted in entanglement, and the harbour porpoises would have faced the risk of drowning if not rescued. Subsequent to these experiences, the harbour porpoises in the study learned from one or more encounters and developed behaviours that reduced their chances of colliding with or becoming entangled in the gillnet (Kastelein *et al.*, 1995). It is important to note that this learning process may not occur in the wild, where animals do not have the opportunity to be rescued. The authors also suggested that harbour porpoises learned to detect the gillnet by using echolocation in complete darkness, highlighting the adaptability of their sensory capabilities in response to the new environmental challenge posed by the gillnet (Kastelein *et al.*, 1995).

720. Read *et al.* (2003) investigated the fine-scale movements of bottlenose dolphins around commercial Spanish mackerel gillnets and found that the most commonly recorded interaction was avoidance, wherein dolphins altered their course to navigate around the net and then resumed their original path once past it. Avoidance behaviours were observed at distances of up to 100 metres from the net (Read *et al.*, 2003). The authors concluded that bottlenose dolphins frequently interact with gillnets but rarely become entangled (Read *et al.*, 2003). When entanglement does occur, it is attributed to dolphins being either unaware of the net or distracted by other stimuli in the net's vicinity, such as fish (Read *et al.*, 2003).

721. Between August 1990 and September 1995, a comprehensive examination of 422 cetacean carcasses representing 12 species that had died around the coasts of England and Wales was conducted (Kirkwood *et al.*, 1997). Among the examined specimens, there were 234 harbour porpoises and 188 individuals from ten other species of dolphins and whales. For the harbour porpoises, the most frequent cause of death was entanglement in fishing gear (Kirkwood *et al.*, 1997). A more recent study by Reeves *et al.* (2013) showed that bycatch continues to affect many odontocete species, as 61 of 74 studied species (82%) have reportedly been bycaught in some kind of fishing gear within their range between 1990 and 2011. Harbour porpoise faces significant challenges due to high bycatch rates in coastal gillnet fisheries across its range, leading to conservation concerns for several populations (Kindt-Larsen *et al.*, 2023).

722. Based on sighting records and a photo-identification catalogue from a grey seal haul-out site in southwest England, Allen *et al.* (2012) reported that over the period from 2004 to 2008, the annual mean entanglement rates fluctuated between 3.6% and 5%. Among the 58 entangled cases in the catalogue, 64% exhibited injuries classified as serious and in 15 cases where the entangling debris was visible, 14 were found to be entangled in fisheries materials (Allen *et al.*, 2012).

723. Statoil (2015) considered the risk of marine mammal entanglement in mooring lines and inter-array cables to be unlikely, but concluded that it is possible for smaller marine mammals (i.e. bottlenose dolphin, harbour porpoise and grey seal) using the offshore area to become entangled in lost or derelict fishing gear which may become entangled in mooring lines and cables. Based on the species most likely at risk, the sensitivity of marine mammals to entanglement was concluded to be low in Statoil (2015). It must be noted that these smaller species (such as bottlenose dolphin and grey seal) are found in lower densities in the Array marine mammal study area, though small cetaceans such as harbour porpoise may be present in greater numbers. Quantifying sensitivity on the basis of little scientific evidence is complex, with only a few examples given to date (Statoil, 2015).

724. It is important to consider that mooring lines and dynamic inter-array cables will undergo regular inspections during the operation and maintenance phase. The inspection frequency for mooring lines and dynamic inter-array cables is anticipated to be more frequent initially (e.g. years 1 and 2), and likely to decline in frequency after this following a risk based approach. Any inspected or detected debris on the floating lines and cables will be recovered based on a risk assessment which considers impact on environment including risk to marine mammal, risk to asset integrity, and health & safety. In addition, Ossian OWFL will consider new technologies for monitoring of mooring lines/snagged gear and will agree approach to monitoring of mooring lines and associated removal of gear with NatureScot and MD-LOT prior to the operation and maintenance phase. This is considered to further reduces the potential risk to marine mammals from secondary entanglement.

### Operation and Maintenance Phase

<u>Berwickshire and North Northumberland Coast SAC</u>

**Grey seal**

725. Given the background information presented in paragraphs 700 to 710, primary entanglement is considered to be rare, with secondary entanglement considered a greater risk where there is potential for accumulation of marine debris on mooring lines. Pinnipeds (such as grey seal) are perceived to be at a lower risk of inadvertently becoming entangled primarily in moorings (as discussed in paragraph 714 to 716) and inter-array cables associated with Array infrastructure (Benjamins *et al.*, 2014). In addition, as discussed in paragraph 717, marine mammals are highly unlikely to experience primary entanglement, given their advanced hearing (such as that of grey seals) and echolocation which would allow them to detect any noise from cables (such as 'bangs', 'creaks', 'rattle', 'snapping' or 'pinging') as described in Burns *et al.* (2022) and Liu (1973). As presented in paragraph 715, pinnipeds, such as grey seals, possess acute mechanosensitivity through their vibrissae or whiskers which may allow them to detect wakes formed downstream of a mooring or cable (Dehnhardt *et al.*, 2001, Hanke *et al.*, 2013). As such, grey seal is deemed to have some resilience to primary entanglement, largely due to avoidance and design of mooring lines/cables.

726. Although the potential risk of secondary entanglement for grey seal is more probable than primary entanglement, the risk is considered to be sufficiently reduced with the application of the designed in mitigation measures (e.g. routine surveys of the moorings and dynamic cabling). As per paragraph 723, grey seal density is relatively low within the Array marine mammal study area, which further reduces risk of secondary entanglement. This, combined with the consideration with the background information summarised in paragraphs 700 *et seq.*, supports the conclusion that population-level effects on grey seal are highly unlikely.

<u>Conclusion</u>

727. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of entanglement during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in in section 6.2.1) are discussed in turn below in Table 6.49.

**Table 6.49: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Entanglement during the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for potential impact between entanglement and the extent, distribution, structure, and function of habitats and the supporting processes of grey seal. Therefore, this potential impact will not prevent these conservation objectives from being maintained. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | As concluded from the background literature reviewed in paragraphs 700 *et seq.*, the risk of entanglement is low and therefore population-level effects on grey seal due to entanglement are not likely to occur. The increased risk of entanglement associated with the Array is highly localised within the vicinity of the cables and will also not affect areas important for breeding and pupping within the SAC, and therefore grey seal will remain a viable component of the site. Overall, including the implementation of designed in mitigation measures (i.e. frequent inspections), entanglement will not prevent the population or distribution of grey seal within the site from being maintained, given low densities of grey seal within the Array marine mammal study area and highly localised impact. |
| | The distribution of qualifying species within the site are maintained | |

728. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of entanglement during the operation and maintenance phase of the Array alone.

Southern North Sea SAC

Harbour porpoise

729. Given the background information presented in paragraphs 700 to 710, primary entanglement is considered to be rare, with secondary entanglement more likely. Harbour porpoise are perceived to be at a lower risk of inadvertently becoming entangled primarily in moorings (as discussed in paragraph 715 to 716) and inter-array cables associated with Array infrastructure (Benjamins *et al.*, 2014). In addition, as discussed in paragraph 717, marine mammals are highly unlikely to experience primary entanglement, given their advanced hearing and echolocation (such as that of VHF cetaceans: harbour porpoise) which would allow them to detect any noise from cables (such as 'bangs', 'creaks', 'rattle', 'snapping' or 'pinging' as described in Burns *et al.* (2022) and Liu (1973). As such, harbour porpoise is deemed to have some resilience to primary entanglement, largely due to avoidance and design of mooring lines/cables.

730. Although the potential risk of secondary entanglement is more probable than primary entanglement, the risk is considered to be sufficiently reduced with the application of the designed in mitigation measures (e.g. routine surveys of the moorings and dynamic cabling). This, combined with the consideration with the background information summarised in paragraphs 700 *et seq.*, supports the conclusion that the risk of entanglement to harbour porpoise is low and therefore population-level effects on harbour porpoise are highly unlikely.

Conclusion

731. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of entanglement during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.50.

**Table 6.50: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Entanglement during the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site | As concluded from the background literature reviewed in paragraphs 700 *et seq.*, population-level effects on harbour porpoise due to entanglement are not likely to occur. The increased risk of entanglement associated with the Array will be highly localised within the vicinity of cables and moorings and will not affect areas important for breeding and calving within the SAC. Therefore, harbour porpoise will remain a viable component of the site. Overall, including the implementation of designed in mitigation, entanglement is not predicted to impact the population from being able to maintain itself as a viable component of the site or cause significant disturbance to the species, given the highly localised nature of this impact. |
| | 2. There is no significant disturbance of the species | |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for potential impact between this potential impact and the habitats, supporting processes, and prey species of harbour porpoise. Therefore, this potential impact will not prevent this conservation objective from being maintained. |

732. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of entanglement during the operation and maintenance phase of the Array alone.

Moray Firth SAC

Bottlenose dolphin

733. Given the background information presented in paragraphs 700 to 710, primary entanglement is considered to be rare, with secondary entanglement likely considered a greater risk where there is potential for accumulation of marine debris on mooring lines. Bottlenose dolphin are perceived to be at a lower risk of inadvertently becoming entangled primarily in moorings and inter-array cables associated with Array infrastructure, due to their ability to echolocate and detect mooring components and their foraging behaviour (as discussed in paragraph 715 to 716) (Benjamins *et al.*, 2014). In addition, as discussed in paragraph 717, marine mammals are highly unlikely to experience primary entanglement, given their advanced hearing and echolocation (such as that of bottlenose dolphin) which would allow them to detect any noise from cables (such as 'bangs', 'creaks', 'rattle', 'snapping' or 'pinging') as described in Burns *et al.* (2022) and Liu (1973). As such, bottlenose dolphin is deemed to have some resilience to primary entanglement, largely due to avoidance and design of mooring lines/cables.

734. Although the potential risk of secondary entanglement is more probable than primary entanglement, the risk is considered to be sufficiently reduced with the application of the designed in mitigation measures (e.g. routine surveys of the moorings and dynamic cabling). This, combined with the consideration with the

background information summarised in paragraphs 700 *et seq.*, supports the conclusion that population-level effects on bottlenose dolphin are highly unlikely.

Conclusion

735. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of entanglement during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.51.

**Table 6.51: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Entanglement during the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site<br>2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance | As concluded from the background literature reviewed in paragraphs 700 *et seq.*, the effects of entanglement are highly localised and population-level effects on bottlenose dolphin due to entanglement are not likely to occur. The increased risk of entanglement associated with the Array will be highly localised within the vicinity of cables and moorings and will also not affect areas important for breeding and calving within the SAC. Further, due to the coastal nature of the bottlenose dolphin feature of the Moray Firth SAC, the likelihood of individuals coming into contact with mooring lines associated with the Array is reduced. Therefore, bottlenose dolphin will remain a viable component of the site. Overall, including the implementation of designed in measures, entanglement is not predicted to impact the population from being able to maintain itself as a viable component of the site or cause significant disturbance to the species given low densities of bottlenose dolphin within the Array marine mammal study area and highly localised impact. |
| | 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained | There is no pathway for potential impact between this potential impact and the habitats, supporting processes, and prey species of bottlenose dolphin. Therefore, this potential impact will not prevent this conservation objective from being maintained. |

736. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of entanglement during the operation and maintenance phase of the Array alone.

## 6.3.6. INJURY AND DISTURBANCE FROM UNDERWATER NOISE GENERATED DURING THE OPERATION OF FLOATING WIND TURBINES AND ANCHOR MOORING LINES

737. The LSE[2] assessment during the HRA Stage One process identified that during the operation and maintenance phase, LSE[2] could not be ruled out for injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines (hereafter: 'operational noise'). This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

738. The MDS considered for the assessment of operational noise is shown in Table 6.52. There are no designed in measures applicable to this impact.

**Table 6.52: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Operational Noise during the Operation and Maintenance Phase**

| Project Phase | MDS | Justification |
|---|---|---|
| Operation and maintenance | Up to 265 semi-submersible floating wind turbine foundations with 224 m hub height, placed 25 m deep in the water column with up to 100 m excursion limit.<br><br>Anchor mooring lines:<br>• up to 1,590 catenary mooring lines;<br>• maximum line length of up to 750 m (measured from the connection at the sea surface to the anchor located at the deepest water depth);<br>• maximum mooring radius of up to 700 m (measured from the anchor to the floater when located at a neutral central point within the excursion limit);<br>• 200 m per mooring line will be dynamic in water column during the operation and maintenance phase with potential increases to 700 m during storms; and<br>• the mooring line attachment to the foundation will be between 15 m above surface to 20 m below sea level.<br>Operation and maintenance phase of up to 35 years. | The maximum scale of the Array as well as the type and dimensions of the floating wind turbines and anchor mooring lines represent the maximum potential for impacts associated with underwater noise during the operational of floating wind turbines and anchor mooring lines. |

### Information to support the assessment

Overview of underwater noise from operational offshore wind farms

739. Throughout the operation and maintenance phase of the Array, there is a potential for mooring lines as well as wind turbine structures to generate underwater noise.

Auditory injury (PTS)

740. As described in paragraph 717, periods of mooring line slackening and tensioning have the potential to produce transient 'pinging' or 'snapping' noises during the operation and maintenance phase of the Array (Liu, 1973). As described in volume 3, appendix 10.1 of the Array EIA Report, the presence of snapping transient noise was identified during acoustic underwater noise measurements at the Hywind Demonstrator Project in Norway in 2011 (Martin *et al.*, 2011). The data was subsequently analysed and Stephenson (2015) extrapolated results from a single wind turbine to a theoretical array and it was found that with up to 115 snapping events per day, the resultant potential cumulative SEL over a 24 hour period was 156 dB re 1 $\mu Pa^2s$ at 150 m from the wind turbines. This value is below the PTS and TTS onset acoustic thresholds for non-impulsive sources (Southall *et al.*, 2019) (Table 6.4).

741. Underwater noise measurements were also taken at the completed Hywind Scotland Pilot Park Project (Burns *et al.*, 2022). The study reported three distinct transient sounds characterised as 'bang', 'creak' and 'rattle' (Burns *et al.*, 2022) and their presence was found to be correlated positively with wave height but to a limited extent with wind speed. The sounds were shown to originate from close to the wind turbine as opposed to further down a mooring line. A quantitative analysis of the impulsiveness of the soundscape at Hywind showed that sounds generated by floating offshore wind farms should be considered as non-impulsive (i.e. continuous) (Burns *et al.*, 2022). The underwater noise measurements found little difference in the daily marine mammal weighted SEL between the Hywind Scotland Pilot Park and control site, and no exceedances of the TTS threshold occurred. The maximum distance at which the TTS could occur across all hearing groups was estimated for harbour porpoise at 50 m from a wind turbine assuming that the animal would remain stationary for the 24 hour period (Burns *et al.*, 2022). Potential TTS ranges for all species are presented in Table 6.53. The study concluded that even at a wind speed of 25 knots, the noise footprint is negligible and in the relatively noisy soundscape of the North Sea, it does not present any realistic threat of auditory injury to marine species.

**Table 6.53: Modelled Maximum Distances to Weighted $SEL_{cum}$ TTS Threshold for 15 Knots Wind Speed (Burns *et al.*, 2022)**

| Species (Hearing Group) | TTS Onset Level (dB re 1 µPa²s) | TTS Range (m) |
|---|---|---|
| Harbour porpoise (VHF) | 153 | 50 |
| Bottlenose dolphin (HF) | 178 | 10 |
| Grey seal (PCW) | 181 | 20 |

742. A recent project by Risch *et al.* (2023a) collected acoustic data from two floating offshore wind farms, currently deployed off the Scottish east coast: Kincardine and Hywind Scotland. At Kincardine, five wind turbines rated at 9.5 MW were deployed on semi-submersible foundations, while at Hywind Scotland five 6 MW rated wind turbines were deployed on spar-buoys. The study found noise emissions from floating turbines were concentrated in the frequencies below 200 Hz, similar to the operational noise of fixed offshore wind turbines, and showed distinct tonal features likely related to rotational speed (between 50 Hz and 80 Hz at Kincardine and 25 Hz and 75 Hz at Hywind Scotland). The median one-third-octave band levels below 200 Hz were between 95 dB re 1 µPa and 100 dB re 1 µPa at about 600 m from the closest wind turbine for both wind farms, well below the level of mild disturbance for cetaceans. The study found the biggest difference between fixed and floating offshore wind turbines in relation to underwater noise generation is mooring-related noise, rather the operational wind turbine noise. Risch *et al.* (2023a), (Risch *et al.*, 2023b) found that during higher wind speeds the number of impulsive sounds or transients from mooring-related structures increased at both Kincardine and Hywind Scotland. Source levels for turbine operational noise (25 Hz to 20 kHz) increased with wind speed at both recording locations, with levels ~3 dB higher at Kincardine than Hywind Scotland which may be due to power ratings or difference in mooring structure (semi-submersible versus spar-buoy). The study predicted noise fields for unweighted sound pressure levels were above median ambient noise levels in the North Sea for maximum distances of 3.5 km to 4.0 km from the Kincardine five wind turbine array, and 3.0 km to 3.7 km for the five wind turbine array at Hywind Scotland. At both floating offshore wind farm locations, recorded harbour porpoise detections were reduced at the recording site closest to the wind turbine compared to the site further away, but Risch *et al.* (2023a) does highlight these floating offshore wind farms have only been operational for a short period and these observed occurrence patterns may change over time as floating offshore wind farms become more mature.

743. While operational noise is continuous, some studies have suggested that it is unlikely that these noise levels would result in physiological damage (Madsen *et al.*, 2006, Marmo *et al.*, 2013, Tougaard *et al.*, 2009a). Early measurements of underwater noise due to operational wind turbines concluded that the underwater noise from operating wind turbines is limited to low frequencies (below 1 kHz) and of low intensity and would therefore be unlikely to affect marine mammals with main hearing sensitivities at higher frequencies (i.e. VHF and HF cetaceans and PCW) (Madsen *et al.*, 2006). Even so, behavioural responses by marine species to operational wind turbine noise appears to be minimal. Modelled predictions by Marmo *et al.* (2013) suggested that only a small proportion (<10%) of harbour porpoises would display behavioural responses up to ~18 km away from an offshore wind farm, and the majority of animals studied would not show a behavioural response, indicating low potential for displacement.

744. Monitoring using acoustic recordings at Horns Rev Offshore Wind Farm in the North Sea revealed, whilst there was a weak adverse effect on harbour porpoise from the construction, no detectable effects were observed on abundance from the operating wind farm (Tougaard *et al.*, 2006). It must be noted however there was a significant difference between when intensive maintenance work took place (termed 'semi-operation') in the study, and operation. Acoustic and ship survey data indicated more porpoises in the area as a whole during the operational period than for any other of the periods, baseline included.

745. However, field measurements and modelling efforts to estimate operational noise levels have predominantly focused on fixed-bottom offshore wind farms in shallow, near-shore environments. Analysis of noise measurements from two Danish (Middelgrunden and Vindeby) and one Swedish (Bockstigen-Valar) fixed-bottom offshore wind farms, concluded that operational noise levels are unlikely to harm or mask acoustic communication in harbour porpoises and harbour seals (Tougaard *et al.*, 2009b). Tougaard *et al.* (2009a) reported at 100 m distance from 1.5 MW wind turbines, underwater sound would be audible to both harbour porpoise and harbour seal. However, at a greater distance of 1,000 m, the signal to ambient sound ratio is too low for detection in harbour porpoise as a VHF cetacean (detection by harbour seal might be possible). Furthermore, the authors caveat these results, as ambient sound values used in this study were extrapolated from measurements obtained in the Baltic and the ambient sound in most parts of the North Sea is much higher and will decrease the radius of detection significantly. The study concluded that the sound is unlikely to exceed injury thresholds at any distance from the wind turbines and was considered incapable of masking acoustic communication by harbour porpoise.

746. Given the information presented in paragraphs 740 *et seq.,* injury in terms of PTS and TTS are unlikely to occur as a result of this impact. Further, the noise modelling presented in Stephenson (2015) and Burns *et al.* (2022) was conducted with the assumption that the marine mammals would remain stationary for 24 hours, which is highly unlikely to occur. Therefore, population-level effects are unlikely to occur for the Annex II marine mammal features of the SACs.

Behavioural disturbance

747. Although the underwater noise study carried out at the completed Hywind Scotland Pilot Park makes no attempt to quantify the disturbance (Burns *et al.*, 2022), the semi-qualitative assessment provided in volume 3, appendix 10.1 of the Array EIA Report concluded that the areas of disturbance are unlikely to extend further than those for fixed wind turbine foundations.

748. The underwater noise from operational offshore wind turbines comes from vibration in the gear box and generator, which is transmitted down the tower and radiated from the tower wall. Given that there is a paucity of qualitative data on sound radiation from the floating offshore wind towers, qualitative assessment is presented with respect to fixed wind turbines (considered as maximum design case when compared to floating). The desktop review carried out in volume 3, appendix 10.1 of the Array EIA Report suggests that although sound levels are likely to be audible within the hundreds of metres from the wind turbine, these will not be at levels sufficient to cause behavioural changes in marine mammals. However, these findings are based on data collected for wind turbines with capacity between 2 MW to 5 MW and a hub height of up to 95 m (see Table 8.27 in volume 3, appendix 10.1 of the Array EIA Report). Recent developments in turbine technology has resulted in larger turbine capacities up to 15 MW now being commercially available from Original Equipment Manufacturers (OEMs). Further developments are anticipated and may result in greater capacities being available to Ossian in early 2030's. The maximum design scenario has been developed to take account of future technological developments with the maximum hub height set at

224 m. Given that the maximum capacity and hub height of wind turbines at the Array may be larger than previously monitored at the Hywind Scotland Pilot Park, it is likely that there will be an increase of a few dB compared to smaller wind turbines. However, considering that the Array will be located in the North Sea with relatively high shipping traffic, the difference in ambient sounds is anticipated to be minimal.

749. Studies using long-term frequency data from wind farms with 5 MW wind turbines (Alpha Ventus, Germany) found that whilst operational sound can be identified, levels hardly exceed beyond ambient sound levels in areas near main shipping traffic routes negligible (Stober *et al.*, 2021). Therefore, marine mammals in high traffic areas may not be able to discern operational wind turbine sound from background levels. Analysis of individual frequencies predicted a correlation between SPLs and the operational status of the wind turbines as well as the wind speed, but the total impact of the operational sound was mostly negligible (Stober *et al.*, 2021). Nedwell *et al.* (2007) analysed measurements of underwater sound inside and outside of four different offshore wind farms in British waters and found operational sound levels were low and only exceeded background levels close to the wind turbines (<1 km).

750. The potential impact of operational noise and the effect of behavioural disturbance are of high reversibility. Although noise levels are likely to be audible to marine mammals, individuals are unlikely to experience significant behavioural disturbance including displacement as a result of the increased underwater noise during operational phase. Therefore, population-level effects are unlikely to occur for the Annex II marine mammal features of the SACs.

### Operation and Maintenance Phase

Berwickshire and North Northumberland Coast SAC

Grey seal

751. Given the background information presented in paragraphs 740 *et seq.,* injury in terms of PTS and TTS and behavioural disturbance are unlikely to occur as a result of this impact. Further, the noise modelling presented in Stephenson (2015) and Burns *et al.* (2022) was conducted with the assumption that the marine mammals would remain stationary for 24 hours, which is highly unlikely to occur given their life history and requirement to surface periodically for air. Therefore, population-level effects are unlikely to occur for grey seal.

Conclusion

752. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of operational noise during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in in section 6.2.1) are discussed in turn below in Table 6.54.

**Table 6.54: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Operational Noise during the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for potential impact between operational noise and the extent, distribution, structure and function of the habitats and supporting processes of grey seal. Therefore, this potential impact will not prevent these conservation objectives from being maintained. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | As concluded from the background literature reviewed in paragraphs 740 *et seq.*, population-level effects on grey seal due to operational noise are not likely to occur. Given that potential injury and disturbance ranges are likely to be small and therefore the impact on grey seal low, operational noise will also not affect areas important for breeding and pupping within the SAC, and therefore grey seal will remain a viable component of the site. Overall, this potential impact will not prevent the population or distribution of grey seal within the site from being maintained. |
| | The distribution of qualifying species within the site are maintained | |

753. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of operational noise in the operation and maintenance phase of the Array alone.

Southern North Sea SAC

Harbour porpoise

754. Given the background information presented in paragraphs 740 *et seq.,* injury in terms of PTS and TTS and behavioural disturbance are unlikely to occur as a result of this impact. Further, the noise modelling presented in Stephenson (2015) and Burns *et al.* (2022) was conducted with the assumption that the marine mammals would remain stationary for 24 hours, which is highly unlikely to occur given their life history and requirement to surface periodically for air. Therefore, population-level effects are unlikely to occur for harbour porpoise.

Conclusion

755. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of operational noise during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.55.

**Table 6.55: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Operational Noise during the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site<br>2. There is no significant disturbance of the species | As concluded from the background literature reviewed in paragraphs 740 *et seq.*, population-level effects on harbour porpoise due to operational noise are not likely to occur. Given that potential injury and disturbance ranges are likely to be small and therefore the potential impact on harbour porpoise low, operational noise will also not affect areas important for breeding and calving within the SAC, and therefore harbour porpoise will remain a viable component of the site. Overall, this potential impact is not predicted to impact the population from being able to maintain itself as a viable component of the site or cause significant disturbance to the species. |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for potential impact between this potential impact and the habitats, supporting processes, and prey species of harbour porpoise. Therefore, this potential impact will not prevent this conservation objective from being maintained. |

756. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of operational noise in the operation and maintenance phase of the Array alone.

Moray Firth SAC

Bottlenose dolphin

757. Given the background information presented in paragraphs 740 *et seq.,* injury in terms of PTS and TTS and behavioural disturbance are unlikely to occur as a result of this impact. Further, the noise modelling presented in Stephenson (2015) and Burns *et al.* (2022) was conducted with the assumption that the marine mammals would remain stationary for 24 hours, which is highly unlikely to occur given their life history and requirement to periodically surface for air. Therefore, population-level effects are unlikely to occur for bottlenose dolphin.

Conclusion

758. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of operational noise during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.56.

**Table 6.56: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Operational Noise during the Operation and Maintenance Phase of the Array Alone**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site<br>2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance | As concluded from the background literature reviewed in paragraphs 740 *et seq.*, population-level effects on bottlenose dolphin due to operational noise are not likely to occur. Given that potential injury and disturbance ranges are likely to be small and therefore the potential impact on bottlenose dolphin low, operational noise will also not affect areas important for breeding and calving within the SAC, and therefore bottlenose dolphin will remain a viable component of the site. Overall, this potential impact is not predicted to impact the population from being able to maintain itself as a viable component of the site or cause significant disturbance to the species. |
| | 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained | There is no pathway for potential impact between this potential impact and the habitats, supporting processes, and prey species of bottlenose dolphin. Therefore, this potential impact will not prevent this conservation objective from being maintained. |

759. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of operational noise in the operation and maintenance phase of the Array alone.

## 6.4. ASSESSMENT OF ADVERSE EFFECTS OF THE ARRAY IN-COMBINATION WITH OTHER PLANS AND PROJECTS

### 6.4.1. PLANS AND PROJECTS SCREENED INTO THE IN-COMBINATION ASSESSMENT FOR ANNEX II MARINE MAMMALS

760. The in-combination effects screening area for marine mammals initially focussed on projects within the regional marine mammal study area (Figure 6.1), as agreed with SNCBs as part of the Ossian Array Scoping Opinion and LSE[2] Screening step (MD-LOT, 2023). The spatial and temporal scale of impacts is critical in the in-combination assessment and has been considered on an impact-by-impact basis to ensure a proportionate approach to the in-combination assessment and is discussed in further detail in paragraph 763.

761. Given the limited data about Tier 3 projects available at the time of writing, projects were screened in initially based on temporal and/or spatial overlap as a precautionary approach. There was limited/no information on the construction/operation dates, nor foundation types proposed, however, with which to undertake a detailed assessment. Therefore, for potential impacts arising from piling, for example, which require these more detailed parameters, there was insufficient information to carry out a full quantitative assessment. A qualitative assessment has been undertaken using the most recent publicly available information for each project.

762. The plans and projects that have been identified as having the potential for in-combination effects are presented in Figure 6.13 and Table 6.57.

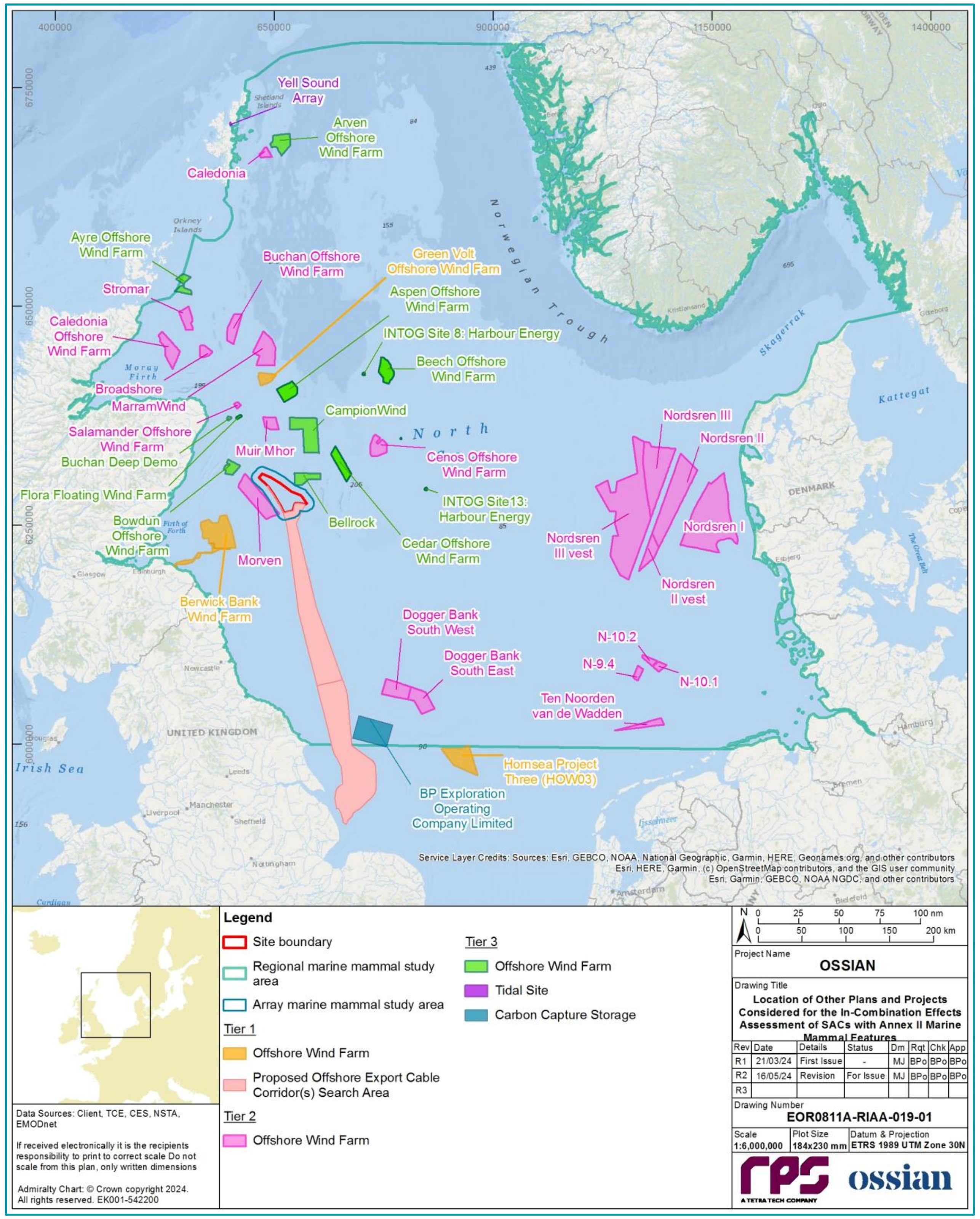


**Figure 6.13: Location of Other Plans and Projects Considered for the In-Combination Effects Assessment on SACs with Annex II Marine Mammals Features**

**Table 6.57: List of Other Plans and Projects with Potential for In-Combination Effects on Annex II Marine Mammal Features**

| Project/Plan | Status [i.e. Application, Consented, Under Construction, Operational] | Distance from Array (km) | Description of Project/Plan | Dates of Construction (If Applicable) | Dates of Operation (If Applicable) | Overlap with the Array |
|---|---|---|---|---|---|---|
| **Tier 1** | | | | | | |
| Proposed offshore export cable corridor(s) | Planned | 0.00 | The Proposed offshore export cable(s) for the Array. | 2030 to 2037 | 2038 to 2072 | Considered as part of the Tier 1 assessment alongside the Array. The construction and operation and maintenance phases of Proposed offshore export cable corridor(s) overlap with those of the Array. |
| **Offshore Wind Projects and Associated Cables** | | | | | | |
| Berwick Bank Wind Farm | Planning | 56.84 | Up to 4.1 GW (up to 307 wind turbines). | 2025 to 2032 | 2033 to 2068 | The construction and operational phase of Berwick Bank overlaps with the construction and operation and maintenance phase of the Array and the operational phases of the Berwick Bank Wind Farm overlap with the construction and operation and maintenance phases of the Array. |
| Green Volt Offshore Wind Farm | Consented | 100.80 | Offshore wind farm proposed for up to 35 wind turbines at a capacity of 560 MW. | 2024 to 2029 | 2030 to 2065 | The operation and maintenance phases of the Green Volt Offshore Wind Farm overlap with those of the Array. |
| Hornsea Project Three (HOW03) | Consented | 319.38 | Offshore wind farm consented for up to 231 wind turbines with no maximum generating capacity. | 2024 to 2030 | 2031 to 2066 | The construction phase of Hornsea Project Three overlaps with the two-year period preceding the construction phase of the Array (therefore screening in for piling), and the operation and maintenance of the Hornsea Project Three overlap with the construction and operation and maintenance phases of the Array. |
| **Tier 2** | | | | | | |
| **Offshore Wind Projects and Associated Cables** | | | | | | |
| Broadshore Hub Offshore Wind Farms | Scoping | 148.14 | Broadshore Hub Offshore Wind Farms (comprising Broadshore Offshore Wind Farm, Sinclair Offshore Wind Farm and Scaraben Offshore Wind Farm) is proposed for up to 72 turbines at a capacity of 1,100 MW across the three projects. | 2028 to 2029 | 2030 onwards | The operation and maintenance phase of Broadshore Hub Offshore Wind Farms overlaps with the construction and operation and maintenance phase of the Array. |
| Buchan Offshore Wind Farm | Scoping | 151.62 | Floating offshore wind farm proposed for up to 60 wind turbines at a capacity of 960MW. | Unknown | Unknown | The construction and operation and maintenance phases of Buchan Offshore Wind Farm overlaps with the construction and operation and maintenance phases of the Array. |
| Caledonia Offshore Wind Farm | Scoping | 157.49 | Caledonia Offshore Wind Farm is proposed for up to 150 wind turbines at a capacity of 2000 MW. | 2028 to 2029 | 2030 onwards | The operation and maintenance phase of Caledonia Offshore Wind Farm overlaps with the construction and operation and maintenance phases of the Array. |
| Cenos Offshore Wind Farm | Scoping | 91.70 | Cenos Offshore Wind Farm is proposed for up to 1350 MW | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Cenos Offshore Wind Farm to overlap with the construction phase and operation and maintenance phase of the Array. |

| Project/Plan | Status [i.e. Application, Consented, Under Construction, Operational] | Distance from Array (km) | Description of Project/Plan | Dates of Construction (If Applicable) | Dates of Operation (If Applicable) | Overlap with the Array |
|---|---|---|---|---|---|---|
| Dogger Bank South East - RWE Renewables | Scoping | 363.35 | Dogger Bank South East is proposed for up to 150 wind turbines at a capacity of 750 MW. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Dogger Bank South East to overlap with the construction and operation and maintenance phases of the Array. |
| Dogger Bank South West - RWE Renewables | Scoping | 499.03 | Dogger Bank South West is proposed for up to 150 wind turbines at a capacity of 750MW. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Dogger Bank South West to overlap with the construction and operation and maintenance phases of the Array. |
| Marram | Scoping | 123.55 | Marram Offshore Wind Farm is proposed for up to 150 turbines at a capacity of 3,000 MW. | 2031 to 2038 | 2039 onwards | The construction phase and operation and maintenance phase of Marram Offshore Wind Farm overlaps with the construction and operation and maintenance phase of the Array. |
| Morven Offshore Wind Farm | Scoping | 5.50 | The Morven Offshore Wind Farm isproposed for up to 191 wind turbines at a capacity of 2,300 MW. | 2031 to 2038 | 2038 onwards | The construction phase and operation and maintenance phases of Morven Offshore Wind Farm overlap with the construction and operation and maintenance phases of the Array. Full overlap between these phases and those of the Array was assumed as a precaution in the absence of available dates for this project. |
| Muir Mhor Offshore Wind Farm | Scoping | 51.38 | Project expected to start construction in 2026 with commercial operation starting in 2030[2] | 2026 to 2029 | 2030 onwards | The operation and maintenance phase of Muir Mhor Offshore Wind Farm overlaps with the construction and operation and maintenance phases of the Array. |
| Salamander Offshore Wind Farm | Scoping | 79.49 | Salamander Offshore Wind Farm is proposed for up to 100 MW. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Salamander Offshore Wind Farm to overlap with the construction phase and operation and maintenance phase of the Array. |
| Nordsren I | Planned | 429.07 | Capacity of up to 17,445 MW. | 2028 to 2029 | 2030 onwards | The operation and maintenance phases of Nordsren I overlaps with the construction and operation and maintenance phases of the Array. |
| Nordsren II | Planned | 395.76 | Capacity of up to 15,000 MW. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Nordsren II to overlap with the construction and operation and maintenance phases of the Array. |
| Nordsren II vest | Planned | 386.65 | Proposed offshore wind farm. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Nordsren II vest to overlap with the construction and operation and maintenance phases of the Array. |
| Nordsren III | Planned | 386.82 | Proposed offshore wind farm. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Nordsren III to overlap with the construction and operation and maintenance phases of the Array. |
| N-10.1 | Planned | 436.69 | N-10.1 Offshore Wind Farm is proposed for up to ten turbines at a capacity of 2,000 MW. | 2028 to 2029 | 2030 onwards | The operation and maintenance phase of N-10.1 overlaps with the construction and operation and maintenance phases of the Array. |
| Nordsren III vest | Planned | 330.10 | Proposed offshore wind farm. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction and operation and maintenance phases of Nordsren III vest to overlap with the construction and operation and maintenance phases of the Array. |

[2] Dates based on latest publicly available information

| Project/Plan | Status [i.e. Application, Consented, Under Construction, Operational] | Distance from Array (km) | Description of Project/Plan | Dates of Construction (If Applicable) | Dates of Operation (If Applicable) | Overlap with the Array |
|---|---|---|---|---|---|---|
| N-10.2 | Planned | 420.78 | N-10.2 Offshore Wind Farm is proposed for up to ten turbines at a capacity of 500 MW. | 2028 to 2029 | 2030 onwards | The operation and maintenance phase of N-10.2 overlaps with the construction and operation and maintenance phases of the Array. |
| N-9.4 | Planned | 421.20 | N-9.4 Offshore Wind Farm is proposed for up to ten turbines at a capacity of 1,000 MW. | 2028 to 2029 | 2030 onwards | The operation and maintenance phase of N-9.4 overlaps with the construction and operation and maintenance phases of the Array. |
| Ten Noorden van de Waddeneilanden | Planned | 437.03 | Ten Noorden van de Waddeneilanden is proposed for a capacity of 700 MW. | 2029 to 2030 | 2031 onwards | The operation and maintenance phase of Ten Noorden van de Waddeneilanden overlaps with the construction and operation and maintenance phases of the Array. |
| Stromar Offshore Wind Farm | Scoping | 170.00 | Floating offshore wind farm with 1,000 MW capacity. | 2025 to 2032 | 2033 to 2059 | The construction phase and operation and maintenance phase of Stromar to overlap with the construction phase and operation and maintenance phases of the Array. |
| **Tier 3** | | | | | | |
| Arven Offshore Wind Farm | Pre-Planning | 363.92 | Floating offshore wind farm with proposed capacity of 3 GW. | Unknown | Unknown | The construction and operation and maintenance phases of Arven Offshore Wind Farm overlaps with the construction and operation and maintenance phases of the Array. |
| Ayre Offshore Wind Farm | Pre-Planning | 219.96 | Floating offshore wind farm with proposed for up to 60 turbines at a capacity of 1000 MW. | Unknown | Unknown | The construction and operation and maintenance phases of Ayre Offshore Wind Farm overlaps with the construction and operation and maintenance phases of the Array. |
| Bellrock Offshore Wind Farm | Pre-Planning | 8.67 | Floating offshore wind farm with proposed capacity of 1,200 MW. | Unknown | Unknown | The operation and maintenance phases of Bellrock overlaps with the construction and operation and maintenance phases of the Array. |
| Bowdun Offshore Wind Farm | Pre-Planning | 25.36 | Offshore wind farm with proposed 60 wind turbines at a capacity of 1000 MW. | Unknown | Unknown | The construction and operation and maintenance phases of Bowdun Offshore Wind Farm overlaps with the construction and operation and maintenance phases of the Array. |
| Campion Offshore Wind Farm | Pre-Planning | 44.15 | Floating offshore wind farm with up to proposed 100 wind turbines at a capacity of 2000MW. | Unknown | Unknown | The construction and operation and maintenance phases of Campion overlaps with the construction and operation and maintenance phases of the Array. |
| Flora Floating Windfarm | Pre-Planning | 68.41 | INTOG project, using floating wind to electrify oil/gas infrastructure. Flora Floating Wind Farm is proposed for up to 50 MW. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Flora Floating Windfarm to overlap with the construction phase and operation and maintenance phase of the Array. |
| Aspen | Pre-Planning | 85.61 | INTOG project, using floating wind to electrify oil/gas infrastructure. Aspen Offshore Wind Farm is proposed for up to 1008 MW. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Aspen to overlap with the construction phase and operation and maintenance phase of the Array. |
| INTOG Site 8: Harbour Energy | Pre-Planning | 154.62 | INTOG project, using floating wind to electrify oil/gas infrastructure. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of INTOG Site 8: Harbour Energy to overlap with the construction phase and operation and maintenance phase of the Array. |

| Project/Plan | Status [i.e. Application, Consented, Under Construction, Operational] | Distance from Array (km) | Description of Project/Plan | Dates of Construction (If Applicable) | Dates of Operation (If Applicable) | Overlap with the Array |
|---|---|---|---|---|---|---|
| Beech | Pre-Planning | 160.41 | INTOG project, using floating wind to electrify oil/gas infrastructure. Beech Offshore Wind Farm is proposed for up to 1008 MW. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Beech to overlap with the construction phase and operation and maintenance phase of the Array. |
| Cedar | Pre-Planning | 51.65 | INTOG project, using floating wind to electrify oil/gas infrastructure. Cedar Offshore Wind Farm is proposed for up to 1008 MW. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Cedar to overlap with the construction phase and operation and maintenance phase of the Array. |
| INTOG Site 13: Harbour Energy | Pre-Planning | 135.28 | INTOG project, using floating wind to electrify oil/gas infrastructure. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of INTOG Site 13: Harbour Energy to overlap with the construction phase and operation and maintenance phase of the Array. |
| Morven Offshore Export Cable Corridor(s) | Pre-Planning | 5.50 | Proposed offshore export cable corridor(s) for Morven Offshore Wind Farm | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of this project to overlap with the construction phase and operation and maintenance phase of the Array. |
| Yell Sound Array | Pre-Planning | 399.72 | Tidal energy array with capacity of 15 MW. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Yell Sound Array to overlap with the construction phase and operation and maintenance phase of the Array. |
| BP Exploration Operating Company Limited | Agreement / Option for Lease | 246.47 | Carbon capture and storage project. | Unknown | Unknown | Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of BP Exploration Operating Company Limited to overlap with the construction phase and operation and maintenance phase of the Array. |

763. The in-combination effects screening area for marine mammals initially focussed on projects within the regional marine mammal study area (Figure 6.1), as agreed with SNCBs during the Ossian Array Scoping Opinion and LSE[2] screening process. The spatial and temporal scale of impacts is critical for the in-combination assessment and has been considered on an impact-by-impact basis to ensure a proportionate approach. For the purposes of this assessment, in-combination impacts have been screened in/out on the following basis per impact:

- **Underwater noise generated during piling (construction phase)** – the ZoI for piling can extend beyond the boundaries of proposed offshore wind farms and therefore, adopting a precautionary approach, the assessment has screened in projects within the regional marine mammal study area whose construction phases overlap with the construction phase of the Array. As a precautionary approach, projects whose construction phase finishes in the two years preceding the commencement of construction phase at the Array (2031) were screened in as the sequential piling at respective projects could lead to a longer duration of effect (i.e. two years prior to 2031). Where a project finishes offshore construction prior to the two years before construction begins, animals are anticipated to recover fully to baseline levels and therefore these projects are screened out on the basis of no receptor impact pathway.
- **Underwater noise during UXO clearance (construction phase)** – the ZoI for UXO clearance can extend beyond the boundaries of other proposed offshore wind farms. Therefore, adopting a precautionary approach, the assessment has screened in projects within 100 km of the site boundary (which is greater than the largest disturbance range of ~32 km for the Array alone) whose construction phases (which would include pre-construction UXO clearance) overlap with the construction phase of the Array. Projects with completed UXO clearance campaigns were screened out of the assessment. Projects whose construction phase finishes in the year preceding the commencement of the Array's construction phase (i.e. one year prior to 2031) were screened in as the sequential UXO clearance at respective projects could lead to a longer duration of effect.
- **Disturbance due to site-investigation surveys (including geophysical surveys) (Construction and operation and maintenance phase)** – it is anticipated that the impacts will be of a similar scale to that described for the Array alone (i.e. metres; see section 6.3.3), with the potential for marine mammals to experience disturbance expected to be localised to within the boundaries of the respective projects. Therefore, the in-combination assessment has focussed only on site-investigation surveys for those projects within the close vicinity (up to 50 km) of the site boundary, and whose construction phase temporally overlaps with that of the Array. For pre-construction phase, where surveys are known to have been completed, this potential impact has been screened out.
- **Effects on marine mammals due to altered prey availability (construction phase)** – potential in-combination effects on fish and shellfish assemblages, as identified in volume 2, chapter 9 of the Array EIA Report, may have indirect effects on marine mammals. For the purposes of the fish and shellfish ecology assessment of effects, in-combination effects have been assessed within a representative 50 km buffer of the fish and shellfish ecology study area. This 50 km buffer applies to all impacts considered in the EIA, except underwater noise, where a larger buffer of 100 km has been used to account for the larger ZoI. Therefore, only the projects considered in volume 2, chapter 9 of the Array EIA Report (and section 5.4 by default) are considered in the assessment of in-combination indirect impacts due to changes in fish and shellfish communities affecting prey availability.
- **Entanglement (operation and maintenance phase)** – this potential impact is included for projects which have operations and maintenance phases that overlap with the operations and maintenance phase of the Array. However, the potential for entanglement would be expected to be localised to within the close vicinity of the respective projects and as such the assessment has focussed only on floating offshore wind projects within a 50 km buffer of the Array as a conservative but proportionate approach.
- **Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines (operation and maintenance phase)** – this potential impact is included for projects which have operations and maintenance phases that overlap with the operations and maintenance phase of the Array. However the potential to experience disturbance by marine mammal receptors would be expected to be localised to within the close vicinity of the respective projects (for example the maximum TTS range for the Array was 50 m) and as such the assessment has focussed only on floating offshore wind projects within a 50 km buffer of the Array as a conservative but proportionate approach. Risch *et al.* (2023b) highlighted the importance of considering the in-combination noise output of large floating offshore wind turbine arrays, particular where boundaries overlap, and therefore the wider 50 km buffer captures this wider spatial scale of effect.

764. The assessment of in-combination effects with relevant projects has focussed on information available in the public domain (e.g. where the potential impact has been identified in the Scoping Report (Tier 2 projects) or the EIA Report and/or RIAA (Tier 1 projects)). In this regard, where an potential impact has been identified and screened in, there is considered to be a potential for in-combination effects and therefore will be considered further in the in-combination assessment. Where impacts have been scoped out from individual assessments of respective projects, they have not been considered further.

765. It should be noted that the in-combination assessment on Annex II marine mammals has been undertaken on the basis of information presented in the EIA Reports for the other plans and projects, which is based upon the respective MDSs.

## 6.4.2. UNDERWATER NOISE GENERATED DURING PILING

766. The LSE[2] assessment during the HRA Stage One process identified that LSE[2] could not be ruled out for underwater noise generated during piling in the construction phase of the Array in-combination with other plans and projects. This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

767. The MDS considered for this in-combination assessment is shown in Table 6.58. The designed in measures are presented in Table 6.8 for the assessment of the Array alone.

**Table 6.58: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Underwater Noise Generated during Piling at the Array In-Combination with other Plans and Projects**

| Project Phase | Tier | MDS |
|---|---|---|
| Construction | 1 | The MDS is as described above for the Array alone (Table 6.7) has been assessed in-combination with the following projects within the regional marine mammal study area and whose offshore construction period finishes within two years of 2031:<br><br>**Construction Phase**<br>• Proposed offshore export cable corridor(s);<br>• Hornsea Project Three; and<br>• Berwick Bank Offshore Wind Farm. |
| | 2 | The MDS is as described above for the Array alone (Table 6.7) has been assessed in-combination with the following projects within the regional marine mammal study area and whose offshore construction period finishes within two years of 2031:<br><br>**Construction Phase**<br>• Broadshore Hub Offshore Wind Farms;<br>• Buchan Offshore Wind Farm;<br>• Caledonia Offshore Wind Farm;<br>• Cenos Offshore Wind Farm;<br>• Dogger Bank South East - RWE Renewables;<br>• Dogger Bank South West - RWE Renewables;<br>• Marram Offshore Wind Farm;<br>• Morven Offshore Wind Farm;<br>• Muir Mhor Offshore Wind Farm;<br>• Salamander Offshore Wind Farm;<br>• Stromar Offshore Wind Farm;<br>• Nordsren I;<br>• Nordsren II;<br>• Nordsren II vest;<br>• Nordsren III;<br>• N-10.1;<br>• Nordsren III vest;<br>• N-10.2;<br>• N-9.4;<br>• Ten Noorden van de Waddeneilanden; and<br>• Tier 1 Projects |
| | 3 | The MDS is as described above for the Array alone (Table 6.7) has been assessed in-combination with the following projects within the regional marine mammal study area and whose offshore construction period finishes within two years of 2031:<br><br>**Construction Phase**<br>• Arven Offshore Wind Farm;<br>• Ayre Offshore Wind Farm;<br>• Bellrock;<br>• Bowdun Offshore Wind Farm;<br>• Campion Offshore Wind Farm;<br>• Flora Floating Wind Farm;<br>• Aspen Offshore Wind Farm;<br>• INTOG Site 8: Harbour Energy;<br>• Beech Offshore Wind Farm;<br>• Cedar Offshore Wind Farm;<br>• INTOG Site 13: Harbour Energy;<br>• Yell Sound Array; |

| Project Phase | Tier | MDS |
|---|---|---|
| | | • BP Exploration Operating Company Limited;<br>• Morven Offshore Export Cable Corridor; and<br>• Tier 1 Projects and Tier 2 Projects. |

### In-combination assessment

768. There is the potential for in-combination impacts from underwater noise generated during piling in the construction phases of the Array and other plans and projects. For the purposes of this assessment, this potential impact has been assessed using the tiered approach outlined in section 4.6. The plans and projects screened into the in-combination assessment for this potential impact and their respective tiers are outlined in Table 6.58.

Tier 1

769. There were three Tier 1 projects identified with potential for in-combination effects associated with this impact:

- the construction and operation and maintenance phases of the Proposed offshore export cable corridor(s);
- the construction and operation and maintenance phases of Berwick Bank; and
- the construction and operation and maintenance phases of Hornsea Project Three (Table 6.58).

770. Whilst the construction phase at Green Volt Offshore Wind Farm is anticipated to be completed in 2029, the Green Volt Offshore Wind Farm EIA (GreenVolt, 2023) states offshore construction is anticipated to take approximately 24 months from quarter four of 2025 to the end of quarter three of 2027 and therefore there is no temporal overlap in piling between Green Volt Offshore Wind Farm and the Array. There will be a period of three years between offshore construction at Green Volt Offshore Wind Farm and the Array and therefore animals are anticipated to recover fully in this period and Green- Volt Offshore Wind Farm will not contribute to the in-combination effect with the Array and is therefore excluded from further assessment.

771. There is no offshore piling during the construction of the construction and operation and maintenance phases of the Proposed offshore export cable corridor(s) and therefore will not contribute to the in-combination effect with the Array and is excluded from the CEA for piling.

772. Piling at each of these Tier 1 projects will occur as a discrete stage within the overall construction phase and therefore the periods of piling may not coincide. These timelines are, however, indicative and may be subject to change, although the realistic worst-case scenario has been considered in this in-combination assessment. Where numbers of animals potentially disturbed are presented, the calculations consider the timelines of respective projects. Given that Hornsea Project Three completes the construction prior to the commencement of construction activities at the Array (see paragraph 776), animals are likely to recover from the disturbance between piling events and therefore the numbers of animals potentially disturbed at respective projects are not added together. If construction timelines directly overlap (such as between Berwick Bank and Hornsea Project Three), animals could be disturbed during piling for both projects simultaneously and therefore numbers of animals potentially disturbed during piling are summed. Nevertheless, to ensure the most precautionary approach, in-combination iPCoD modelling incorporates numbers of animals affected by all Tier 1 projects throughout construction phases.

773. The potential to experience auditory injury in terms of PTS by marine mammal receptors as a result of underwater noise due to piling would be expected to be localised to within the boundaries of the respective projects (assuming similar ranges of effect as presented for the Array). It is also anticipated that standard offshore wind industry construction methods (which include soft starts and visual and acoustic monitoring of marine mammals as standard) will be applied, thereby reducing the magnitude of the potential impact with respect to auditory injury occurring in marine mammals. Therefore, there is no potential for significant in-combination impacts for injury from elevated underwater noise during pilling and the in-combination assessment focuses on disturbance only.

774. Each project screened in has a slightly different approach to assessing behavioural disturbance of cetaceans and pinnipeds. For many years since it was published, Southall *et al.* (2007) along with Lucke *et al.* (2009) was widely used to assess the effects of noise on marine mammals, and was used in the assessment of disturbance for Dogger Bank Creyke Beck A, Dogger Bank Creyke Beck B (Forewind, 2014). This represents a fixed-threshold value approach, where it is assumed that all animals within the predicted impact area are to display a behavioural reaction, while none of the animals outside this area will react. However, since then a dose-response curve derived using received noise level and harbour porpoise presence data (Graham *et al.*, 2017) was used to determine the proportion of animals present likely to be displaced in assessments for projects such as Inch Cape (Inch Cape Offshore Limited, 2018), Moray West (Moray West OWF Limited, 2018c) and Hornsea Project Three (Ørsted, 2018a), Hornsea Project Four (Ørsted, 2021) and the Array. Given that respective projects used different criteria and noise thresholds modelled for marine mammal receptors in their assessments, it is necessary to exercise considerable caution if attempting any comparison between results of these appraisals. There are also variations between projects in the way results are presented. Some projects present the range of area from which animals are excluded and numbers of animals disturbed, whilst others only present number of animals disturbed and no ranges. Various densities were used to derive these numbers of animals (e.g. data from the integrated cetacean analysis (Mackenzie *et al.*, 2012) and combined site-specific density surface and SCANS III Block data at Hornsea Project Three). As these values come from different sources, density details may reflect various densities of respective species throughout the year (i.e. seasonal versus average across the year). Respective projects may also use different reference populations. Therefore, assessment of the potential effects on marine mammals predicted by other wind farms is not always directly comparable to those presented the Array due to different approaches to assessment taken by other offshore developers, different noise criteria and thresholds used, and differing levels of detail presented in associated EIAs.

775. The construction phase of Berwick Bank Offshore Wind Farm is expected to run from 2025 to 2032 with the final piling phase in 2031 (SSE Renewables, 2022c), therefore offshore construction may overlap with the construction phase of the Array by two years, and an overlap of piling for one year and therefore lead to in-combination effects from piling. Located 56.84 km south-west from the site boundary, the MDS for piling at Berwick Bank Offshore Wind Farm assumed that 5.5 m diameter piled jacket foundations will be installed using a maximum hammer energy of 4,000 kJ. The EIA states piling will be required at up to 179 wind turbine foundations and ten OSP/Offshore convertor station platform foundations, with the MDS based on concurrent piling at wind turbine foundations with the largest separation between piling locations as this leads to the MDS for disturbance (piling could occur concurrently at a wind turbine and OSP/Offshore convertor station platform foundation but these locations would be closer together compared to two wind turbine foundations). The maximum number of days (24 hours) within which piling could occur on the basis of two piling operations was 287 piling days (concurrent vessel) for the 179 wind turbines and 85 piling days (single vessel) for the ten OSPs/Offshore convertor station platforms. Piling activity at Berwick Bank Offshore Wind Farm will take place in three campaigns, and an indicative piling schedule was presented in the iPCoD report which gives a realistic installation programme (SSE Renewables, 2022a), and this was carried forward to population modelling presented in volume 2, chapter 10 of the Array EIA Report. With mitigation measures in place (MMO[2], PAM, ADD for 30 minutes, low hammer initiation, soft start and ramp up, such as those in Table 6.7 for the Array alone), the residual number of individuals potentially affected by PTS was zero for all species. Numbers of animals disturbed for marine mammal IEFs, as presented in the Berwick Bank Offshore Wind Farm EIA (SSE Renewables, 2022c), is given in Table 6.59.

**Table 6.59 Numbers of Animals Predicted to be Disturbed as a Result of Underwater Noise During Piling for Berwick Bank Offshore Wind Farm (SSE Renewables, 2022c)**

| Species | Scenario | Number of Animals | Magnitude | Residual Significance |
|---|---|---|---|---|
| Harbour porpoise | Concurrent Piling Wind Turbine (1% conversion factor) | 2,822 | Low | Minor adverse significance |
| | Single Piling OSP/Offshore Convertor Station Platform | 1,754 | | |
| Bottlenose dolphin | Concurrent Piling Wind Turbine (1% conversion factor) | 5 (Coastal)<br>102 (Offshore) | Low | Minor adverse significance |
| | Single Piling OSP/Offshore Convertor Station Platform | 4 (Coastal)<br>64 (Offshore) | | |
| Grey seal | Concurrent Piling Wind Turbine (1% conversion factor) | 1,358 | Low | Minor adverse significance |
| | Single Piling OSP/Offshore Convertor Station Platform | 705 | | |

776. The construction of Hornsea Project Three is anticipated to occur until 2030 (Table 6.57), one year prior to the construction of the Array. Therefore, whilst the construction of Hornsea Project Three will be completed prior to commencement of piling at the Array, it could lead to a longer duration of piling operations (i.e. sequential rather than concurrent piling). It must be noted however that Hornsea Three is at the furthest extent of the regional marine mammal study area (a very small overlap therefore was screened in), located 319.38 km from the Array, and therefore in-combination effects are highly unlikely at this distance. The regional marine mammal study area is a precautionary screening area for assessment to account for the mobile nature of marine mammals and does not account for the levels of precaution in each respective projects MDS assessment (see paragraph 462 *et seq* for examples of conservatism in underwater noise modelling*)*. The in-combination assessment of Hornsea Project Three is based upon the EIA submitted alongside the application for Development Consent Orders to the Planning Inspectorate (Ørsted, 2018a). As detailed in the EIA, piling at Hornsea Three is likely to occur in two short phases (each of approximately one year and a half), with a maximum duration of three years between phases where no piling will occur, and it is expected animals will recover in this period.

777. The MDS for marine mammals for Hornsea Project Three included both a maximum spatial scenario and maximum temporal scenario. The maximum spatial scenario consisted of concurrent piling of 319 monopiles (300 turbine foundations and 19 foundations for other infrastructure and platform foundations) installed over 193.8 days, which comprises 189 days for monopiles over a 2.5 year period (divided into two phases and a gap of up to three years between phases), and 4.8 days for offshore High Voltage Alternating Current (HVAC) booster (over eight months within the 2.5 year piling period, single piling only), with a maximum hammer energy of up to 5,000 kJ (although Ørsted (2018a) noted typically the maximum hammer energy will be considerably less than this and would not be required at all locations). The MDS states concurrent piling will occur only for infrastructure located within the Hornsea Three Array Area and not for infrastructure located within the offshore HVAC booster station search area in which only a single vessel scenario is possible.

778. The maximum temporal scenario for Hornsea Project Three consisted of single piling of 1,848 pin piles (1,200 for jacket foundations and 648 for other infrastructure and platform foundations) over 554.4 days, over a 2.5 year period with two phases and a gap of up to three years between phases, and 28.8 days for offshore HVAC booster over eight months within the 2.5 year piling period), with an absolute maximum hammer energy of up to 2,500 kJ.

779. The assessment in Hornsea Three was based on the definition of MDS piling parameters for each turbine foundation type (i.e. 5,000 kJ hammer energy for the monopiles and 2,500 kJ for the pin piles), however both a 'most likely' ramp up scenario (i.e. maximum hammer energy for most of the piling events = 3,500 kJ hammer energy for monopiles and 1,750 kJ for pin piles) and an overall 'average' hammer energy were defined (i.e., average typical hammer energy = 2,000 kJ for monopiles and 1,500 kJ for pin piles). Ørsted (2018a) stated the number of animals disturbed under the maximum design scenario is highly precautionary as these hammer energies will not be representative of most of the actual piling activity. Whilst five representative locations were modelled, the highest impact ranges were found at the north-east modelling location within the Hornsea Three array (Hornsea Three NE) and at the south modelling location within the HVAC search area (HVAC S) and therefore used in the assessment for cetaceans. For grey seal, the Hornsea Three north-west (NW) location overlapped with higher seal density areas and therefore used for the assessment for grey seal. For concurrent scenarios, the MDS was modelled for monopiles at locations Hornsea Three NE and NW.

780. A range of density estimates were used for the assessment of disturbance at Hornsea Three, as presented in Table 6.60, alongside the dose-response method (Graham *et al.* (2017) for harbour porpoise and Russell *et al.* (2016) for grey seal (bottlenose dolphin were not included in the assessment)). It should be noted that dose-response is not an area-based approach (see paragraphs 446 *et seq.*), and numbers of animals potentially impacted cannot be accurately attributed to the populations of specific SACs. Numbers of animals potentially disturbed from Hornsea Project Three are discussed for their respective SACs below in paragraphs 797 *et seq.*

**Table 6.60 Density Estimates used in Hornsea Project Three Assessment of Piling (Ørsted, 2018a)**

| Species | Site-specific Density Estimate | Wider Area (Beyond Survey Area) |
|---|---|---|
| Harbour porpoise | • Density surface modelled using acoustic survey data collected over Hornsea Zone plus 10 km buffer<br>• Corrected density from DAS surveys of Hornsea Three study area | SCANS III |
| Grey seal | • Seal-usage maps (Russell *et al.*, 2017) | SCANS III |

Tier 2

781. There were 20 Tier 2 projects identified with potential for in-combination effects associated with this impact:

- Broadshore Hub Offshore Wind Farms
- Buchan Offshore Wind Farm;
- Caledonia Offshore Wind Farm;
- Buchan Offshore Wind Farm;
- Dogger Bank South East – RWE Renewables;
- Dogger Bank South West – RWE Renewables;
- Marram Offshore Wind Farm;
- Morven Offshore Wind Farm;
- Muir Mhor Offshore Wind Farm;
- Salamander Offshore Wind Farm;
- Stromar Offshore Wind Farm;

- Nordsren I;
- Nordsren II;
- Nordsren II vest;
- Nordsren III;
- N-10.1';
- Nordsren III vest;
- N-10.2;
- N-9.4; and
- Ten Noorden van de Waddeneilanden (Table 6.58).

782. Broadshore Hub Offshore Wind Farms are located 148.14 km from the Array and includes areas of seabed as part of INTOG leasing rounds to develop the 900 MW Broadshore Offshore Wind Farm Project (the Broadshore Project), the 99.5 MW Sinclair Offshore Wind Farm Project (the Sinclair Project) and the 99.5 MW Scaraben Offshore Wind Farm Project (the Scaraben Project), collectively known as the Broadshore Hub Offshore Wind Farms (Broadshore Offshore Wind Farm Limited *et al.*, 2024). All projects will comprise wind turbines, station keeping systems and inter-array cables. The Broadshore Project will comprise up to 60 wind turbines, whilst the Sinclair and the Scaraben Projects will comprise up to six wind turbines. The Broadshore Hub Offshore Wind Farms Scoping Report (Broadshore Offshore Wind Farm Limited *et al.*, 2024) scoped in underwater noise during impact piling (using hydraulic hammer or vibropiling) of anchors of fixed bottom substructures and/or floating substructures. Anchor driven piles may have up to 12 anchor driven piles per floating substructure estimated at 3.5 m diameter with hammer energy of up to 3,000 kJ. Fixed bottom substructures may comprise either jacket (tripod or quadruped) up to 4 m pile with hammer energy of up to 4,000 kJ, either impact or drill piled, or cable supported monopile with pile diameter of 16 m. The construction phase is expected to begin in 2028 until 2029 and therefore piling will be completed a year prior to the start of the Array, allowing some recovery before piling begins at the Array. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

783. Buchan Offshore Wind Farm is located 151.62 km from the Array and is a floating offshore wind farm with up to 70 wind turbines and associated supporting structures, including floating foundations, mooring systems and anchors, inter-array cables, up to three OSPs and export cable corridor (Buchan Offshore Wind Limited, 2023). The Buchan Offshore Wind Farm scoped in increased underwater noise from pile driving for floating wind turbines, OSPs and Intermediate Reactive Compensation (IRC) platform (if piled foundations are used). The construction phase is expected to begin in 2028 until 2030 and therefore piling may be sequential with the start of the construction of the Array, however the large distance means cumulative effects are unlikely. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

784. The Caledonia Offshore Wind Farm is located in the Moray Firth, 157.49 km north from the site boundary, indicatively 75% of the Caledonia Offshore Wind Farm's Array Area could be constructed using fixed foundations, and is considering the use of floating foundations for remaining sites (Ocean Winds, 2022). Fixed-foundation types currently being considered include: monopile; fully restrained platform; jacket with pin piles; jacket with suction caissons; Gravity Based Structure (GBS). Floating foundation types include semi-submersible and tension leg platform. A maximum of 150 wind turbine generators will be located within the Array Area, with an estimated split of up to 111 fixed foundations and 39 floating foundations. An indicative spatial distribution on fixed foundations (an area approximately 307 km2 across the north of the Caledonia Array Area) and floating foundations (approximately 122 km2 across the south of the Caledonia Array Area) is presented within the Offshore Scoping Report. The MDS considers up to six OSPs. The final type and design for the foundations will be subject to further site investigations, however jacket with pin piles, jacket with suction caissons, monopile and GBS currently under consideration. The construction phase is expected to begin in 2028 until 2029 and therefore piling will be completed a year prior to the start of the Array, allowing some recovery before piling begins at the Array. Information on the numbers of animals potentially affected is not available at this time to undertake a quantitative assessment.

785. Cenos Offshore Wind Farm is located 91.70 km from the Array and is a proposed floating offshore wind farm (part of the INTOG leasing process) with up to 1.4 GW and footprint of 333 km$^2$. The Cenos Offshore Wind Farm Scoping Report (Flotation Energy, 2023) gives potential development size of 70 to 100 turbines with floating substructures with 3 to 6 mooring lines/anchor substructures. The Cenos Offshore Wind Farm scoped in underwater noise from percussion piling as a potential impact on marine mammals, but stated no significant effects on marine mammals due to noise are expected (Flotation Energy, 2023). The Cenos Offshore Wind Farm Scoping Report details an indicative schedule from 2027 to 2030 with installation of all the turbines expected to take two to three years, and therefore piling may be sequential with the start of the construction of the Array. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

786. Dogger Bank South Offshore Wind Farms comprise Dogger Bank South East (located 363.35 km south from the site boundary) and Dogger Bank South West (located 499.03 km south from the site boundary). The Project Description allows for up to 150 turbines for each project, and the Scoping Report details a range of foundation options, including monopiles, jackets on pin piles; and jackets on suction buckets (RWE Renewables UK, 2022). Construction of the Dogger Bank Offshore Wind Farms is expected to begin no earlier than 2026, however the programme for construction will depend on the final confirmation of the grid connection date and there is no indication currently of a construction timeline (therefore on a precautionary basis it is considered there may be some overlap with the Array's construction phase). It is anticipated that the two Dogger Bank projects will be built concurrently and sequentially (RWE Renewables UK, 2022). The large distance between the Dogger Bank South Offshore Wind Farms and the Array means in-combination effects are unlikely.

787. The Morven Offshore Wind Farm is a proposed large scale fixed-foundation offshore wind farm located 5.50 km west from the site boundary. The Offshore Scoping Report (Morven Offshore Wind Limited, 2023) considers up to 191 wind turbines and up to 11 OSPs. The following foundation types will be considered: monopile foundations, gravity base foundations, piled jacket foundations (three or four legs for wind turbines; three, four or six legs for OSPs), suction bucket jacket foundations (three or four legs for wind turbines; three, four or six legs for OSPs) (Morven Offshore Wind Limited, 2023). The construction phase of the Morven Array Project is estimated to occur from 2031 to 2038, meaning a potential for full overlap with the construction phase of the Array. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

788. Muir Mhor Offshore Wind Farm is a floating offshore wind project located 51.38 km north-west from the site boundary, comprising up to 67 wind turbine foundations with a spacing of ≥ 1000 m. The turbines will be supported by a floating foundation with associated mooring and anchoring systems to keep the foundation 'on station'. There are a number of floating foundation types under consideration, which include: semi-submersible, barge, tension leg platform, spar, multi-tower semi- submersible, buoy and semi-spar (Fred Olsen Seawind *et al.*, 2023). The construction of the Muir Mhor Ooffshore wind Wind farm Farm is expected to occur between 2027 and 2030, and therefore whilst there is potential for no direct temporal overlap with the Array construction phase, piling at the Muir Mhor Offshore Wind Farm could lead to a longer duration of piling operations (i.e. sequential piling). Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

789. Salamander Offshore Wind Farm (Simply Blue Energy (Scotland) Limited, 2023) is located 79.49 km from the Array and is a proposed floating wind farm with an installed capacity of up to 100 MW. Up to seven offshore wind turbines with supporting floating substructures and mooring and anchoring systems, inter-array cables Underwater noise associated with piling activity is scoped in (from potential installation of piles associated with the mooring and anchoring system) in the Salamander Offshore Wind Farm Scoping Report (Simply Blue Energy (Scotland) Limited, 2023). A detailed construction programme with specific construction dates is not given in the scoping report, therefore a potential temporal overlap with construction at the Array cannot be discounted, but an indicative construction programme presents offshore construction from Q2 in year two and year three for six months per time, therefore potential temporal overlap is limited. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

790. Stromar is located 170 km away from the site boundary, with the Stromar Array Area approximately 256 km$^2$ in size. The EIA states up to 71 wind turbines with associate floating wind turbine substructures, with mooring and anchoring systems and inclusion of dynamic and static inter-array/interlink cable and up

to three OSPs. Floating substructures may include spar, tension-leg platform, semi-submersible and barge (Stromar Offshore Wind Farm, 2024). The indicative programme presented in the EIA assumes Stromar become commercially operational between 2030 and 2033 and has an offshore construction programme of six years (7 years construction phase for onshore and offshore). Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

791. For Nordsren I, Nordsren II, Nordsren II vest, Nordsren III, N-10.1, Nordsren III vest, N-10.2, N-9.4 and Ten Noorden van de Waddeneilanden, whilst scoping reports cannot be obtained, it has been assumed piling is scoped in as a precautionary approach to assessment. However, these projects lie between ~330 km and ~437 km away from the site boundary and therefore any in-combination effect from piling is highly unlikely given the contours presented for piling for the Array alone (section 6.3.1).

Tier 3

792. There were 11 Tier 3 projects identified within the regional marine mammal study area with potential for in-combination effects associated with this impact:

- Arven Offshore Wind Farm;
- Ayre Offshore Wind Farm;
- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm;
- Flora Floating Wind Farm;
- Aspen Offshore Wind Farm;
- INTOG Site 8: Harbour Energy;
- Beech Offshore Wind Farm;
- Cedar Offshore Wind Farm;
- INTOG Site 13: Harbour Energy;
- Yell Sound Array;
- BP Exploration Operating Company Limited; and
- Morven Offshore Export Cable Corridor (Table 6.58).

793. Tier 3 projects are in the pre-application phase and no EIA Scoping Report, EIA Report, or HRA documentation is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

794. The construction of the Array, together with construction phase of Tier 1, Tier 2 and Tier 3 projects may lead to in-combination injury and disturbance to marine mammals from underwater noise generated during piling.

795. The data in relation to Tier 3 projects available at the time of writing is limited and it is not possible to carry out a quantitative assessment. This is particularly the case for INTOG projects, where little is known about the scale of the potential environmental impacts associated with these projects, though it is likely that many will be floating projects. Tier 3 projects were screened in on a precautionary basis due to their location (they lie within the regional marine mammal study area), though there is limited/no information on the construction/operation dates or project design with regards to piling. It should be acknowledged that there is a potential for piling activities to be taking place and therefore projects cannot be discounted, however it is not possible to undertake quantified assessment for potential in-combination impacts as a result of elevated underwater noise due to uncertainty in piling schedules for Tier 3 projects. Therefore, a qualitative assessment has been undertaken to determine in-combination impacts with tier 3 projects.

796. There is no publicly available piling parameters or published assessments for Tier 3 projects (which are at pre-scoping stage), however given the phase of development, temporal overlap with the Array may be limited. Furthermore, given the maximum injury ranges for the Annex II marine mammal species associated with piling from the Array (maximum PTS range of 1,600 m modelled for harbour porpoise), there is low likelihood of any spatial overlap of ranges between the Array and the Tier 3 projects. For example, the closest Tier 3 projects are the Morven Offshore Export Cable Corridor (5.5 km away) and Bellrock Offshore Wind Farm (8.67 km away), which both far exceed the maximum PTS range for all species. Further, the potential for PTS is reduced through the application of designed-in measures, and animals are expected to be able to flee the injury zone due to ADD activation prior to commencement of soft starts (Table 6.11). Therefore there is limited potential for an in-combination impact associated with the Tier 3 projects, and each project will likely implement their own mitigation to limit injury and disturbance as per the JNCC (2010c) guidelines, thus further reducing the potential for in-combination effects associated with piling.

## Construction phase

Berwickshire and North Northumberland Coast SAC

**Grey seal**

*Tier 1*

797. As presented in paragraphs 769 *et seq.,* there were three Tier 1 projects identified with potential for in-combination effects, and two projects (Berwick Bank and Hornsea Project Three) assessed as part of the Tier 1 assessment.

798. The assessment for Berwick Bank Wind Farm (SSE Renewables, 2022c) predicted up to 1,358 animals have the potential to be disturbed from concurrent piling at a maximum hammer energy of 4,000 kJ (3.19% of the East Scotland plus Northeast England SMU populations), based upon Carter *et al.* (2020) maps (Table 6.61). Grey seal could also be potentially disturbed within the zone of possible disturbance during single piling at a wind turbine or an OSPs/Offshore convertor station platform at a maximum hammer energy of 4,000 kJ with up to 705 animals disturbed (1.66% of the East Scotland plus Northeast England SMU populations). In the Berwick Bank EIA, population modelling for grey seal against the SMU populations showed that the median of the ratio of the impacted population to the unimpacted population was 1 (100%) at 25 years and it was considered that there is no potential for a long-term effect on this species. The magnitude for Berwick Bank Wind Farm, for behavioural impacts from piling on grey seal, was considered to be low (SSE Renewables, 2022c).

799. Within the RIAA for Berwick Bank Wind Farm, there was predicted to be a small overlap with northern part of the Berwickshire and North Northumberland Coast SAC with the unweighted $SEL_{ss}$ 145 dB re 1 $\mu Pa^2 s$ behavioural disturbance contour for grey seal (SSE Renewables, 2022e). This threshold of 145 dB re 1 $\mu Pa^2 s$ was used as it was the level at which behavioural responses have been observed in seals (Whyte *et al.*, 2020). However, the RIAA concluded that although there is a potential for overlap of disturbance contours with northern section of the SAC, it is the southern half of the SAC which is an important breeding site for grey seals (SCOS, 2020). The RIAA concluded that grey seals present in the southern part of the SAC, in the vicinity of the habitats which they utilise throughout their life cycle (submerged/partially submerged sea caves, intertidal mud/rock/sediment), are therefore unlikely to experience disturbance as these areas lie outside of the noise disturbance contours. As such, piling at Berwick Bank Wind Farm was concluded to be highly unlikely to disrupt normal behaviours of grey seals or adversely affect maintenance of the supporting habitats (SSE Renewables, 2022e).

800. The assessment for Hornsea Project Three predicted 53 grey seal to be exposed to behavioural disturbance during concurrent piling events (monopiles), based upon noise contours overlain on grey seal at-sea density surfaces from Russell et al. (2017) (Table 6.61). Given that Hornsea Project Three completes construction prior to the commencement of construction activities at the Array, animals are likely to recover from the disturbance between piling events and therefore the numbers of animals potentially disturbed at respective projects are not added together. Hornsea Project Three is 319.38 km away from the site boundary and is located in the southern North Sea between England and the Netherlands (Figure 6.13). It is located 266 km away from the Berwickshire and North Northumberland Coast SAC, and this SAC was assessed in the RIAA for Hornsea Project Three (Ørsted, 2018b). The Hornsea Project Three

RIAA presented no spatial overlap between the unweighted $SEL_{ss}$ noise disturbance contours and this SAC (Ørsted, 2018b).

**Table 6.61: Grey Seal In-Combination Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 1 Projects**

| Project | Hammer energy | Scenario | Number of Animals Disturbed | SMU used in EIA | % Reference Population | Residual Impact |
|---|---|---|---|---|---|---|
| The Array | Maximum hammer energy up to 4,400 kJ + 3,000 kJ | Concurrent piling of wind turbine and OSP | 436 | 36,696 East Scotland and Northeast England SMUs | 1.19% | Low |
| Berwick Bank Wind Farm (SSE Renewables, 2022c) | Maximum hammer energy up to 4,000 kJ | Concurrent piling wind turbines | 1,358 | 42,600 East Scotland and Northeast England SMUs | 3.19% | Low |
| | | Single OSPs | 705 | | 1.65% | |
| Hornsea Three (Ørsted, 2018a) | Maximum hammer energy up to 4,000 kJ | Concurrent piling wind turbines | 53 | 40,040 Southeast England and Northeast England SMUs | 0.13% | Low |

801. Population modelling (see volume 3, appendix 10.3 of the Array EIA Report) considered Berwick Bank Wind Farm and Hornsea Project Three alongside the Array (a quantitative assessment for Proposed offshore export cable corridor(s) is not available at this stage), with respective numbers of animals potentially impacted against the combined SMUs reference population. Results of the in-combination iPCoD modelling for grey seal showed that the median of the ratio of impacted population to unimpacted population was 1 at all modelled time points, and there was no difference in the mean size of the impacted and unimpacted populations at all time points. Therefore, it was considered that there is no potential for a long-term effect on this species as a result of in-combination piling at the Array and respective Tier 1 projects.

802. Based on the information presented in paragraphs 797 *et seq.*, it is concluded that piling in-combination at the Array and the Tier 1 projects will not have an adverse effect on the integrity of grey seal feature of this SAC.

*Tier 2*

803. The Tier 2 assessment, presented in paragraphs 781 *et seq.,* concluded that in-combination effects as a result of piling in the construction phase are unlikely to occur. This is largely due to the distance between many Tier 2 projects and the site boundary (i.e. often over hundreds of kilometres). Further, piling at the Tier 2 projects will be intermittent, and the effects of behavioural disturbance are reversible. Based on this, it is concluded that piling in-combination at the Array and the Tier 2 projects will not have an adverse effect on the integrity of grey seal feature of this SAC.

*Tier 3*

804. The Tier 3 assessment, presented in paragraphs 792 *et seq.,* highlighted that it was not possible to undertake quantitative in-combination assessment for the 11 Tier 3 projects identified for this impact. This was due to the lack of publicly available information surrounding piling parameters and lack of information in general about INTOG projects. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 3 projects.

805. There is no publicly available piling parameters or published assessments for Tier 3 projects (which are at pre-scoping stage), however given the phase of development, temporal overlap with the Array may be limited. Furthermore, given the maximum injury ranges for grey seal associated with piling from the Array (maximum PTS range of 379 m modelled for the Array alone), there is low likelihood of any spatial overlap of ranges between the Array and the Tier 3 projects. For example, the closest Tier 3 projects are the Morven Offshore Export Cable Corridor (5.5 km away) and Bellrock Offshore Wind Farm (8.67 km away), which both far exceed the maximum PTS range for grey seal. Further, the potential for PTS is reduced through the application of designed-in measures, and animals are expected to be able to flee the injury zone due to ADD activation prior to commencement of soft starts (Table 6.11). Therefore there is limited potential for an in-combination impact associated with the Tier 3 projects, and each project will likely implement their own mitigation to limit injury and disturbance as per the JNCC (2010c) guidelines, thus further reducing the potential for in-combination effects associated with piling.

806. Based on this, it is concluded that piling in-combination at the Array and the Tier 3 projects will not have an adverse effect on the integrity of grey seal feature of this SAC.

*Conclusion*

807. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.1) are discussed in turn below in Table 6.62.

**Table 6.62: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Underwater Noise Generated During Piling in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for potential impact between underwater noise generated during in-combination piling and the extent, distribution, structure, and function of the habitats and supporting processes of grey seal (i.e. no overlap with the area of significant disturbance with the SAC). Therefore, the extent, distribution, structure, and function of the habitats and supporting processes of grey seal will not be adversely affected by this potential impact from the Array in-combination with the Tier 1, 2, and 3 projects. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | Overall, in-combination piling during the construction phase is unlikely to lead to injury or strong behavioural responses. The in-combination assessment has concluded that piling at the Tier 1, 2, and 3 projects is highly unlikely to disrupt the population or distribution of grey seal associated with this SAC (paragraphs 797 *et seq.*). Therefore, the populations and distribution of grey seal are not likely to be impacted by injury and disturbance associated with piling from the Array in-combination with the Tier 1, 2, and 3 projects.<br><br>As for the assessment of the Array alone, iPCoD modelling of the Tier 1 projects indicated that there would be no significant difference between the population trajectories for the unimpacted (baseline) population and the impacted population (paragraph 801). It was therefore considered that there would be no potential long-term effects on the population or distribution of grey seal.<br><br>The Tier 1 assessment (which used the dose-response method and/or conversion factors depending on the project) presented the most conservative estimates of numbers of animals predicted to be potentially disturbed (Table 6.61). Low percentages of the relevant SMU populations were predicted to be impacted (i.e. up to 3.19%). It should be noted that these estimates are not area-based and the number of animals potentially disturbed cannot be attributed to the SAC population. Given that grey seals are likely to return to the piling area on subsequent trips following cessation of piling, it will not result in any long-term changes in the distribution of seals from this SAC and the connectivity with areas of high importance within and outside the site is not expected to be impaired (such as foraging grounds). |
| | The distribution of qualifying species within the site are maintained | |

808. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of underwater noise generated during piling with respect to the construction phases of the Array in-combination with other plans and projects.

<u>Southern North Sea SAC</u>

**Harbour porpoise**

*Tier 1*

809. As presented in paragraphs 769 *et seq.,* there were three Tier 1 projects identified with potential for in-combination effects, and two projects (Berwick Bank and Hornsea Project Three) able to be assessed as part of the Tier 1 assessment.

810. The assessment for Berwick Bank Wind Farm predicted up to 2,822 harbour porpoise (based on seasonal peak density) are predicted to experience potential disturbance from concurrent piling at a maximum hammer energy of 4,000 kJ (SSE Renewables, 2022c), which equates to 0.81% of the North Sea MU population and 7.3% of SCANS III Block R estimated abundance (Table 6.63). This was based upon a 1% conversion factor and peak seasonal density of 0.826 animals per $km^{2,}$ assuming all animals are uniformly distributed within all noise contours to provide a precautionary assessment. The EIA stated the duration of piling could potentially affect harbour porpoise over a maximum of five breeding cycles, with the magnitude of the potential impact having the potential to result in a small but measurable alteration to the distribution of marine mammals during piling only (372 days over 52 months) and may affect the fecundity of small proportion of the population (up to 0.81% of the North Sea MU at any one time) over the medium term (Table 6.63). Results of the iPCoD modelling for Berwick Bank Wind Farm for harbour porpoise against the MU population showed that the median of the ratio of the impacted population to the unimpacted population was 0.99 at 25 years regardless of the conversion factor scenario assessed (SSE Renewables, 2022c) and therefore, it was considered that there is no potential for a long-term effect. The magnitude for Berwick Bank Wind Farm, for behavioural impacts from piling, was considered to be low.

811. Within the RIAA for Berwick Bank Wind Farm, behavioural disturbance to harbour porpoise was based on the unweighted $SEL_{ss}$ contours using conversion factors (SSE Renewables, 2022e), so is not the same as the approach taken for the assessment for the Array alone. There was no potential for overlap between the modelled unweighted $SEL_{ss}$ disturbance contours modelled from 180 out to 120 dB re 1 $\mu Pa^2s$ and the Southern North Sea SAC predicted for Berwick Bank Wind Farm (SSE Renewables, 2022e), however it should be noted that this is not an area-based approach and numbers of animals potentially affected cannot be attributed solely to the SAC population.

812. The assessment for Hornsea Project Three predicted up to 7,330 harbour porpoises to be exposed to behavioural disturbance during concurrent piling events (monopiles), by combining the site-specific density surface estimates and the SCANS III density data (where potential impact areas extended beyond the mapped survey area). The North Sea MU harbour porpoise reference population was used for this assessment (227,298 individuals (Ørsted, 2018a)). The effect of disturbance of harbour porpoise from piling was predicted to be of minor adverse significance. Cumulative iPCoD modelling for Hornsea Project Three on the North Sea MU harbour porpoise population as a result of a number of scenarios of offshore wind farm construction was carried out for the CEA within the Hornsea Project Three EIA (Ørsted, 2018a)). The assessment found that even with 15% of the population potentially disturbed due to multiple Tier 2 projects (Dogger Bank Creyke Beck A, Dogger Bank Creyke Beck B, Dogger Bank Teesside A, Dogger Bank Teesside B (Sofia) and East Anglia Three), there was only a small (6%) increase in the risk of an annual population decline of 1% per year and that overall, impacted population trajectories were not significantly different from baseline population trajectories (Ørsted, 2018a).

813. Given that Hornsea Project Three completes the construction prior to the commencement of construction activities at the Array, animals are likely to recover from the disturbance between piling events and therefore the numbers of animals potentially disturbed at respective projects are not added together. However, there is the potential overlap of one year of piling with Berwick Bank Wind Farm which may lead to in-combination effects. Up to 11,131 animals may be disturbed if concurrent piling of wind turbines at Berwick Bank Wind Farm and concurrent piling at the Array occur simultaneously (Table 6.63). However,

Berwick Bank Wind Farm is located 56.84 km from the Array, and the likelihood of in-combination effects with projects located at large distances is considered to be reduced.

814. Hornsea Project Three is 319.38 km away from the site boundary and is located in the southern North Sea between England and the Netherlands (Figure 6.13). It is located 2 km away from the Southern North Sea SAC, and was assessed in the RIAA for Hornsea Project Three (Ørsted, 2018b). The 140 dB and 160 dB (rms) contours for mild and strong disturbance were not included in the RIAA, neither was the 143 dB ($SEL_{ss}$) disturbance contour (Ørsted, 2018b). However, 26 km buffers were used to assess disturbance associated with piling, equivalent to the 26 km EDR recommended in the JNCC (2020) guidance which was published after the Hornsea Project Three RIAA. The RIAA concluded that only the piling for the HVAC booster stations could overlap with the winter component of the SAC (the northern portion) based on the 26 km disturbance buffers (Ørsted, 2018b). This equated to a maximum of four piling days over the winter season (182 days). Considering a return time of 72 hours an additional two days was added onto every piling day, resulting in 14.4 days. Therefore, the percentage overlap over the winter component, was 0.046%. The RIAA approach was stated to be over precautionary as it assumed no overlap between one set of piling events plus return time and the next piling event plus return time. It additionally considers the HVAC piling occurring during both the winter and summer seasons (Ørsted, 2018b).

815. Many projects refer to the North Sea MU as a reference population, which, as presented in the original Seagreen EIA (Seagreen Wind Energy Limited, 2012) stretches across an area of 750,000 km$^2$. The number of harbour porpoise potentially disturbed has been considered for projects located in the marine mammal study area, which means some, including Hornsea Three, lie over 300 km from the Array. Delineating the spatial extent of in-combination effects is commonly acknowledged as a challenge. Although harbour porpoise is generally rare in waters >200 m depth, the fact that this species utilises such a vast area further complicates a choice of appropriate spatial scale (Clarke Murray *et al.*, 2014). Given the vast extent of available habitat, the fact that harbour porpoise is a wide-ranging species and the low percentage of the North Sea MU population disturbed as a result of piling at respective projects, the likelihood of in-combination effects with projects located at large distances (e.g. >100 km) from the site boundary (i.e. Hornsea Three) is considered to be low.

**Table 6.63 Harbour Porpoise In-Combination Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 1 Projects**

| Project | Hammer energy | Scenario | Number of Animals Disturbed | MU used in EIA | % Reference Population | Residual Impact presented in EIA |
|---|---|---|---|---|---|---|
| The Array | Maximum hammer energy up to 4,400 kJ + 3,000 kJ | Concurrent piling of wind turbine and OSP | 8,309 | 346,601 NS MU (IAMMWG, 2022) | 2.40% | Low |
| Berwick Bank Wind Farm (SSE Renewables, 2022c) | Maximum hammer energy up to 4,000 kJ | Concurrent piling wind turbines | 2,822 | 346,601 NS MU (IAMMWG, 2021) | 0.81% | Low |
| | | Single OSPs | 1,754 | | 0.51% | |
| Hornsea Three (Ørsted, 2018a) | Maximum hammer energy up to 4,000 kJ | Concurrent piling wind turbines | 7,330 | 227,298 NS (IAMMWG, 2015) | 3.22% | Low |
| | | Single (offshore booster stations) | 964 | | 0.42% | |

816. As undertaken for the assessment of the Array alone (paragraph 541), an EDR approach has also been used for the assessment of disturbance associated with piling during the construction phase for harbour porpoise features in-combination with other plans and projects. The maximum EDR of 26 km was used for the Array alone, with the southern piling location representing the closest distance to the SAC (Figure 6.8). Only two in-combination projects were relevant for inclusion: Berwick Bank Wind Farm (Tier 1) and Morven Offshore Wind Farm (Tier 2). This is based on their proximity to the site boundary and public availability of their potential piling parameters. Although there are some Tier 3 projects in close proximity to the site boundary (such as Bellrock and Bowdun Offshore Wind Farms), there are no publicly available piling parameters, and the construction schedules are still unknown, so they can only be assessed as Tier 3 projects. Based on publicly available piling parameters in respective EIAs and scoping reports (Morven Offshore Wind Limited, 2023, SSE Renewables, 2022c), including monopiles, 26 km EDRs have been plotted for Berwick Bank Wind Farm and Morven Offshore Wind Farm (Figure 6.14) to assess the potential for in-combination disturbance to the Southern North Sea SAC. It should be noted that as individual modelled piling locations are not currently publicly available for these projects (unlike the Array) and so a 26 km EDR buffer region has been drawn around the entire project boundaries, as opposed to precise maximum piling locations. Therefore, these 26 km EDRs plotted for Berwick Bank and Morven Wind Farms are overly precautionary. Given that there is no overlap between these EDRs and the Southern North Sea SAC, the conclusion that there will not be an in-combination impact to this SAC is further supported.

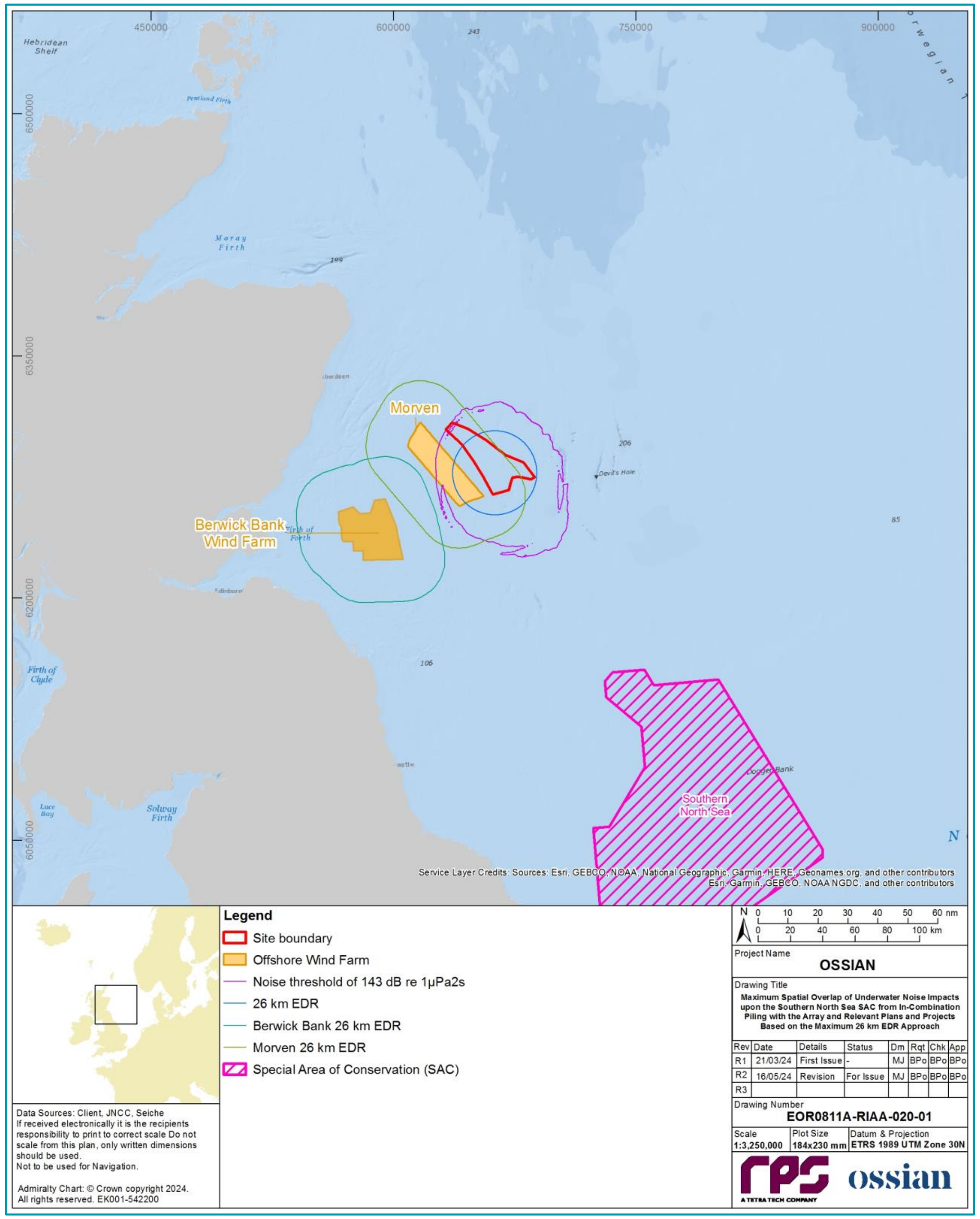


**Figure 6.14: Maximum Spatial Overlap of Underwater Noise Impacts upon the Southern North Sea SAC from In-Combination Piling with the Array and Relevant Plans and Projects Based on the Maximum 26 km EDR Approach**

817. Population modelling (see volume 3, appendix 10.3 of the Array EIA Report) considered Berwick Bank Wind Farm and Hornsea Project Three alongside the Array, with respective numbers of animals potentially impacted against the MU population. The construction phase of Hornsea Project Three ends in 2030, prior to the commencement of the Array construction phase. Furthermore, there is a three-month period at the start of each year in which no piling will take place for the Array, thus allowing a further cessation of the potential impact between the two projects. Results of the in-combination iPCoD modelling for harbour porpoise showed that the median of the ratio of impacted population to unimpacted population approaches a ratio of 1 at all modelled time points. Although there was a difference in the number of animals between the disturbed and undisturbed populations, it was not considered that there is a potential for a long-term effect on this species as a result of in-combination piling at the Array and respective Tier 1 projects.

818. Based on the information presented in paragraphs 809 *et seq.*, it is concluded that piling in-combination at the Array and the Tier 1 projects will not have an adverse effect on the integrity of harbour porpoise feature of this SAC.

*Tier 2*

819. The Tier 2 assessment, presented in paragraphs 781 *et seq.,* concluded that in-combination effects as a result of piling in the construction phase are unlikely to occur. This is largely due to the distance between many Tier 2 projects and the site boundary (i.e. often over hundreds of kilometres). Further, piling at the Tier 2 projects will be intermittent, and the effects of behavioural disturbance are reversible. As presented in Figure 6.14, the 26 km EDR for the Tier 2 Morven Offshore Wind Farm will not overlap with the Southern North Sea SAC and therefore does not contribute to the in-combination impact of the Array. Based on this, it is concluded that piling in-combination at the Array and the Tier 2 projects will not have an adverse effect on the integrity of harbour porpoise feature of this SAC.

*Tier 3*

820. The Tier 3 assessment, presented in paragraphs 792 *et seq.,* highlighted that it was not possible to undertake a quantitative in-combination assessment for the 11 Tier 3 projects identified for this impact. This was due to the lack of publicly available information surrounding piling parameters and lack of information in general about INTOG projects. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 3 projects.

821. There is no publicly available piling parameters or published assessments for Tier 3 projects (which are at pre-scoping stage), however given the phase of development, temporal overlap with the Array may be limited. Furthermore, given the maximum injury ranges for harbour porpoise associated with piling from the Array (maximum PTS range of 1,600 m modelled for the Array alone), there is low likelihood of any spatial overlap of ranges between the Array and the Tier 3 projects. For example, the closest Tier 3 projects are the Morven Offshore Export Cable Corridor (5.5 km away) and Bellrock Offshore Wind Farm (8.67 km away), which both far exceed the maximum PTS range for harbour porpoise. Further, the potential for PTS is reduced through the application of designed-in measures, and animals are expected to be able to flee the injury zone due to ADD activation prior to commencement of soft starts (Table 6.11). Therefore there is limited potential for an in-combination impact associated with the Tier 3 projects, and each project will likely implement their own mitigation to limit injury and disturbance as per the JNCC (2010c) guidelines, thus further reducing the potential for in-combination effects associated with piling.

822. Based on this, it is concluded that piling in-combination at the Array and the Tier 3 projects will not have an adverse effect on the integrity of harbour porpoise feature of this SAC.

*Conclusion*

823. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.64.

**Table 6.64: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Underwater Noise Generated During Piling in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site | Overall, in-combination piling during the construction phase is unlikely to lead to injury or strong behavioural responses. The in-combination assessment has concluded that piling at the Tier 1, 2, and 3 projects is highly unlikely to disrupt the population or distribution of harbour porpoise associated with this SAC (paragraphs 809 *et seq.*).<br><br>It should be noted that the respective EIAs and RIAAs for the Tier 1 projects did not use the unweighted $SEL_{ss}$ 143 dB re 1µPa²s or 140 dB and 160 dB (rms) disturbance contours, as per the approach taken for the Array alone. However, no significant potential impact and adverse effect on integrity of this SAC was predicted in the EIAs and RIAAs, respectively, of the Tier 1 projects (Berwick Bank Wind Farm and Hornsea Project Three). The in-combination maximum areas of disturbance based on the 26 km EDRs from JNCC (2020) do not overlap with the Southern North Sea SAC (Figure 6.14), and therefore animals are unlikely to experience significant disturbance within the site from the Array in-combination with the other plans and projects. Given the wide-ranging nature of harbour porpoise, it is unlikely that noise contours would result in barrier effects restricting harbour porpoise from reaching key habitats within the SAC. In-combination piling will therefore not affect areas important for breeding and calving within the SAC, and therefore harbour porpoise will remain a viable component of the site. Overall, underwater noise generated during in-combination piling is not predicted to impact the objective of the population being able to maintain itself as a viable component of its natural habitat over the long term. |
| | 2. There is no significant disturbance of the species | The Tier 1 assessment (which used the dose-response approach and/or conversion factors depending on the project) presented the most conservative estimates of number of animals predicted to be disturbed (Table 6.63). Low percentages of the North Sea MU population were predicted to be impacted (i.e. up to 3.22%). It should be noted that these estimates are not area-based and the number of animals potentially disturbed cannot be attributed to the SAC population. Further, harbour porpoise is likely to return to the piling area on subsequent trips following cessation of piling. Finally, the results of the in-combination iPCoD modelling undertaken for the EIA demonstrated that there would be no long-term population effects. Underwater noise generated during piling from the Array in-combination with other plans and projects is therefore not predicted to impact the objective of no significant disturbance of the species within the site. |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for potential impact between underwater noise generated during in-combination piling and the habitats and supporting processes of harbour porpoise. With respect to the prey species of harbour porpoise, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.4.5), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support harbour porpoise will not be adversely affected by this potential impact from the Array in-combination with the Tier 1, 2, and 3 projects. |

824. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of underwater noise generated during piling with respect to the construction phases of the Array in-combination with other plans and projects.

Moray Firth SAC

**Bottlenose dolphin**

*Tier 1*

825. As presented in paragraphs 769 *et seq.,* there were three Tier 1 projects identified with potential for in-combination effects, and two projects (Berwick Bank and Hornsea Project Three) were screened in and assessed as part of the Tier 1 assessment. Bottlenose dolphin was not scoped in as a key species for Hornsea Project Three (Ørsted, 2018a), therefore this project is excluded from the Tier 1 assessment. However, bottlenose dolphin was considered in Berwick Bank Wind Farm (SSE Renewables, 2022c) and therefore can be included in the in-combination assessment for Tier 1.

826. Berwick Bank Wind Farm (SSE Renewables, 2022c) used a dual metric approach to estimate bottlenose dolphin disturbed. The EIA used noise contours overlaid with 2 m to 20 m depth contours and calculated numbers of animals in those areas, using a density of 0.197 animals per km² from Peterhead to Farne Islands and 0.294 animals per km² for the outer Firth of Tay (where the density is higher). Furthermore, the number of bottlenose dolphins potentially disturbed during piling in offshore areas was calculated using densities from SCANS III Block R data (0.0298 animals per km²). Up to five bottlenose dolphins are predicted to have the potential to experience disturbance from concurrent piling in coastal waters (2.25% of the Coastal East Scotland MU population) based upon 1% constant conversion factor and maximum hammer energy of 4,000 kJ (SSE Renewables, 2022c) (Table 6.65). Coastal bottlenose dolphin could also be potentially disturbed during single piling at a wind turbine or an OSPs/Offshore convertor station platform, with up to four (1.49% of the Coastal East Scotland MU population) animals affected (SSE Renewables, 2022c) (Table 6.65).

827. Potential effects on the offshore bottlenose dolphin population were also assessed in the EIA for Berwick Bank Wind Farm. During concurrent piling at maximum 4,000 kJ hammer energy, up to 102 individuals occurring in offshore waters have the potential to experience disturbance (5.29% of SCANS III Block R). For the single piling scenario, up to 64 individuals have the potential to experience disturbance offshore, which equates to 3.29% of the SCANS III Block R estimated abundance. The EIA did state the densities were considered to be conservative as these are based on highly precautionary coastal and offshore density estimates. Population modelling for bottlenose dolphin against the MU population showed that the median of the ratio of the impacted population to the unimpacted population was a ratio of 1 at 25 years and there was no potential for a long-term effect on this species. The magnitude for Berwick Bank Wind Farm, for behavioural impacts from piling, was considered to be low.

828. Within the RIAA for Berwick Bank Wind Farm, there was no potential for overlap between the 140 dB and 160 dB (rms) noise disturbance contours and the Moray Firth SAC (SSE Renewables, 2022e). Up to five animals from the Moray Firth SAC population were predicted to experience mild disturbance but this is unlikely to lead to barrier effects as animals are unlikely to be excluded from the coastal areas. Given that modelled noise contours in Berwick Bank Wind Farm did not extend to the Moray Firth SAC and animals are expected to experience only mild behavioural disturbance within the Coastal East Scotland MU, behavioural disturbance is unlikely to alter the distribution of bottlenose dolphin such that recovery cannot be expected, or effects can be considered long term (SSE Renewables, 2022e).

829. There is potential overlap of one year of piling at the Array with Berwick Bank Wind Farm, which may lead to in-combination effects. Up to ten animals (in the Coastal East Scotland MU) may be disturbed if concurrent piling of wind turbines at Berwick Bank Wind Farm and concurrent piling at the Array occur simultaneously. However, Berwick Bank Wind Farm is located 56.84 km south-east from the Array, and the likelihood of in-combination effects with projects located at large distances is considered to be reduced.

**Table 6.65 Bottlenose Dolphin In-Combination Assessment – Numbers of Animals Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 1 Projects**

| Project | Hammer energy | Scenario | Number of Animals Disturbed | MU Reference Population used in EIA | % Reference Population | Residual Impact |
|---|---|---|---|---|---|---|
| The Array | Maximum hammer energy up to 4,400 kJ + 3,000 kJ | Concurrent piling of wind turbine and OSP | 5 | 224 Coastal East Scotland MU (IAMMWG, 2023) | 2.23% | Low |
| Berwick Bank Wind Farm (SSE Renewables, 2022c) | Maximum hammer energy up to 4,000 kJ | Concurrent piling wind turbines | 51 | 224 Coastal East Scotland MU (Arso Civil *et al.* 2019) | 2.23% | Low |
| | | Single OSPs | 41 | | 1.79% | |

830. Population modelling (see volume 3, appendix 10.3 of the Array EIA Report) considered Berwick Bank Wind Farm alongside the Array (a quantitative assessment for Proposed offshore export cable corridor(s) is not available and Hornsea Three did not assess bottlenose dolphin/it lies outside of the Coastal East Scotland MU), with respective numbers of animals potentially impacted against the MU population. For bottlenose dolphin, the Coastal East Scotland MU was used as the relevant reference population for in-combination population modelling. Given the importance of the Moray Firth SAC for bottlenose dolphin in this area, the sensitivity of this population and its known ranging behaviour further south towards St Andrews Bay and the Tay Estuary, and inshore in north-east English waters, it is important to capture the potential impact on this important coastal ecotype which may experience potential barrier effects. Whilst there is an abundance estimate for the Greater North Sea MU (2,022 animals (IAMMWG, 2023)) this large MU extends the entire length of the east coast of the UK and east to Scandinavia, so apportioning numbers of the offshore ecotype to the east coast of Scotland is not possible. It is also unlikely that the Array will create significant barrier effects for this offshore ecotype. Therefore, the in-combination modelling assessment for the Array used the Coastal East Scotland MU as the relevant reference population.

831. Results of the iPCoD modelling for bottlenose dolphin undertaken for the EIA showed that the median of the ratio of impacted population to unimpacted population approaches had a ratio of 1 at all modelled time points, with ten fewer animals in the impacted population at 25 years after the start of piling, compared to the impacted population. Therefore, it was not considered that there is potential for a long-term effect on this species as a result of piling at the Array and respective Tier 1 projects within the Array EIA Report (volume 2, chapter 10). Furthermore, given the population modelling used the Coastal East Scotland MU, and the site boundary sits outside of this MU (by approximately 50 km west from the site boundary at the closest point), it is considered further unlikely to have long-term effects on the offshore ecotype.

*Tier 2*

832. The Tier 2 assessment, presented in paragraphs 781 *et seq.,* concluded that in-combination effects as a result of piling in the construction phase are unlikely to occur. This is largely due to the distance between many Tier 2 projects and the site boundary (i.e. often over hundreds of kilometres). Further, piling at the Tier 2 projects will be intermittent, and the effects of behavioural disturbance are reversible. Based on this, it is concluded that piling in-combination at the Array and the Tier 2 projects will not have an adverse effect on the integrity of bottlenose dolphin feature of this SAC.

*Tier 3*

833. The Tier 3 assessment, presented in paragraphs 792 *et seq.,* highlighted that it was not possible to undertake any quantitative in-combination assessment for the 11 Tier 3 projects identified for this impact. This was due to the lack of publicly available information surrounding piling parameters and lack of information in general about INTOG projects. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 3 projects.

834. There is no publicly available piling parameters or published assessments for Tier 3 projects (which are at pre-scoping stage), however given the phase of development, temporal overlap with the Array may be limited. Furthermore, given the maximum injury ranges for bottlenose dolphin associated with piling from the Array (maximum PTS range of 171 m modelled for the Array alone), there is low likelihood of any spatial overlap of ranges between the Array and the Tier 3 projects. For example, the closest Tier 3 projects are the Morven Offshore Export Cable Corridor (5.5 km away) and Bellrock Offshore Wind Farm (8.67 km away), which both far exceed the maximum PTS range for bottlenose dolphin. Further, the potential for PTS is reduced through the application of designed-in measures, and animals are expected to be able to flee the injury zone due to ADD activation prior to commencement of soft starts (Table 6.11). Therefore there is limited potential for an in-combination impact associated with the Tier 3 projects, and each project will likely implement their own mitigation to limit injury and disturbance as per the JNCC (2010c) guidelines, thus further reducing the potential for in-combination effects associated with piling.

835. Based on this, it is concluded that piling in-combination at the Array and the Tier 2 projects will not have an adverse effect on the integrity of bottlenose dolphin feature of this SAC.

*Conclusion*

836. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during piling in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.66.

**Table 6.66: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Underwater Noise Generated During Piling in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site | Overall, in-combination piling during the construction phase is unlikely to lead to injury or strong behavioural responses. The in-combination assessment has concluded that piling at the Tier 1, 2, and 3 projects is highly unlikely to disrupt the inshore population of bottlenose dolphin associated with this SAC.<br><br>The only project with an available EIA and RIAA and that had included bottlenose dolphin as a receptor was Berwick Bank Wind Farm (Tier 1). No significant potential impact and adverse effect on integrity of this SAC was predicted in the EIA and RIAA of Berwick Bank Wind Farm. There was no potential for overlap between the 140 dB and 160 dB (rms) noise disturbance contours from the Berwick Bank Wind Farm and the Moray Firth SAC, in-combination with those of the Array. It is unlikely that noise contours from Berwick Bank and the Array would result in barrier effects restricting bottlenose dolphin from reaching key habitats within the SAC. In-combination piling will therefore not affect areas important for breeding and calving within the SAC, and therefore bottlenose dolphins will remain a viable component of the site. Overall, underwater noise generated during in-combination piling is not predicted to impact the objective of the population being able to maintain itself as a viable component of its natural habitat over the long term. |
| | 2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance | The Tier 1 assessment (which included conversion factors as used for Berwick Bank, and dose-response as used by the Array alone in the EIA Report) presented the most conservative estimates of animals predicted to be disturbed (Table 6.65). Low percentages of the Coastal East Scotland MU population were predicted to be impacted at the Array and Berwick Bank (i.e. up to 2.23% for each). It should be noted that these estimates are not area-based and the number of animals potentially disturbed cannot be attributed to the SAC population. Further, the results of the iPCoD modelling undertaken for the EIA demonstrated that there would be no long-term population effects. Underwater noise generated during piling from the Array in-combination with other plans and projects is therefore not predicted to impact the distribution of bottlenose dolphin throughout the site. |
| | 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained | There is no pathway for potential impact between underwater noise generated during in-combination piling and the habitats and supporting processes of bottlenose dolphin. With respect to the prey species of bottlenose dolphin, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.4.5), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support bottlenose dolphin will not be adversely affected by this potential impact from the Array in-combination with the Tier 1, 2, and 3 projects. |

837. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of underwater noise generated during piling with respect to the construction phases of the Array in-combination with other plans and projects.

## 6.4.3. UNDERWATER NOISE GENERATED DURING UXO CLEARANCE

838. The LSE[2] assessment during the HRA Stage One process identified that LSE[2] could not be ruled out for underwater noise generated during UXO clearance in the construction phase of the Array in-combination with other plans and projects. This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

839. The MDS considered for this in-combination assessment is shown in Table 6.67. The designed in measures are presented in Table 6.19 for the assessment of the Array alone.

**Table 6.67: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Underwater Noise Generated During UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Project Phase | Tier | MDS |
|---|---|---|
| Construction | 1 | The MDS is as described above for the Array alone (Table 6.18) assessed in-combination with the construction of the following marine projects within the 100 km buffer and whose construction phase finishes in the year preceding the commencement of construction phase of the Array (2030):<br>• Proposed offshore export cable corridor(s); and<br>• Berwick Bank Offshore Wind Farm. |
| | 2 | The MDS is as described above for the Array alone (Table 6.18) assessed in-combination with the construction of the following marine projects within the 100 km buffer and whose construction phase finishes in the year preceding the commencement of construction phase of the Array (2030):<br>• Cenos Offshore Wind Farm;<br>• Morven Offshore Wind Farm;<br>• Muir Mhor Offshore Wind Farm;<br>• Salamander Offshore Wind Farm; and<br>• Tier 1 projects. |
| | 3 | The MDS is as described above for the Array alone (Table 6.18) assessed in-combination with the construction of the following marine projects within the 100 km buffer and whose construction phase finishes in the year preceding the commencement of construction phase of the Array (2030):<br>• Bellrock Offshore Wind Farm;<br>• Bowdun Offshore Wind Farm;<br>• Campion Offshore Wind Farm;<br>• Flora Floating Wind Farm;<br>• Aspen Offshore Wind Farm;<br>• Cedar Offshore Wind Farm;<br>• Morven Offshore Export Cable Corridor(s); and<br>• Tier 1 and 2 projects. |

In-combination assessment

840. There is the potential for in-combination impacts from underwater noise from UXO clearance in the construction phase of the Array and other plans and projects. For the purposes of this assessment, this potential impact has been assessed using the tiered approach outlined in section 4.6. The plans and projects screened into the in-combination assessment for this potential impact and their respective tiers are outlined in Table 6.67.

Tier 1

841. There were two Tier 1 projects within the 100 km buffer identified with potential for in-combination effects associated with this impact:

- the construction phases of the Proposed offshore export cable corridor(s); and
- the construction phases of Berwick Bank Wind Farm (Table 6.67).

842. Potential impacts of underwater noise from UXO detonations on marine mammals include mortality, physical injury or auditory injury. The risk of injury in terms of PTS to marine mammal receptors as a result of underwater noise during UXO clearance would be expected to be localised to the vicinity around the boundaries of the respective projects. It also is anticipated that standard offshore wind industry mitigation methods (which include visual and acoustic monitoring of marine mammals as standard and additional mitigation in form of ADDs and/or soft start charges) will be applied based on UXO specific risk assessment and if any residual risk of injury remains it will be mitigated further post-consent, thereby reducing the severity of the potential impact with respect to auditory injury occurring in marine mammals. However, the potential for a residual risk of injury was investigated based on the UXO clearance technique and mitigation proposed for each project.

843. As previously presented for the Array alone in paragraph 560 *et seq*. (which uses TTS as a proxy for disturbance), the duration of effect for each UXO detonation is less than one second and behavioural effects are therefore considered to be negligible in this context.

844. Projects screened in for this in-combination assessment are expected to involve similar construction activities to those described for the Array alone, including UXO clearance activities. It is anticipated that, for all projects, impacts associated with these activities will also require additional assessment under EPS licensing.

845. Berwick Bank Wind Farm based their assessment on 14 UXOs requiring clearance (SSE Renewables, 2022c) (Table 6.68) (up to 70 UXOs are likely to be found within the Berwick Bank Array Area and the Berwick Bank Proposed offshore export cable corridor(s), however, only 14 of these will require clearance based upon experience at Seagreen Wind Energy Ltd (2021)) and noise modelling was undertaken for UXO clearance (both low order and high order detonation) using the methodology described in Soloway *et al.* (2014). The EIA did state the precise details and locations of potential UXOs was unknown at the time of assessment. For the purposes of the UXO assessment, it was assumed that the maximum design scenario is UXO size up to 300 kg, and the maximum frequency would be up to two detonations within 24 hours. Berwick Bank Wind Farm stated low order techniques will be applied as the intended methodology for clearance of UXO (in which case in-combination effects would be further reduced) however, highlighted there is a small risk that a low order clearance could result in high order detonation of UXO, and some UXOs may need to be cleared with high order methods and therefore whilst both low and high order clearance was assessed, the MDS was based upon high order clearance (300 kg).

**Table 6.68 UXO Clearance Parameters for the Array and Berwick Bank Wind Farm**

| Project | UXO Clearance Method | Maximum UXO Size Assessed (kg) | | Number of UXOs |
|---|---|---|---|---|
| | | PTS | Disturbance (TTS) | |
| The Array | High order detonation | 698 | 698 | 15 |
| Berwick Bank | High order detonation | 300 | 300 | 14 |
| Total | | | | 29 |

**Auditory injury (PTS)**

846. For a given marine mammal hearing group, exceedance of the threshold for the onset of PTS may result in a permanent hearing loss which in turn could inhibit ecological functioning, such as communication, foraging, navigation, and predator avoidance. The inability to continue with these important activities could eventually lead to a decline in vital rates of an individual, including growth, reproduction and subsequently survival. Depending on the type of detonation and size of UXO, UXO clearance activities may have residual effects in respect to marine mammals and PTS injury. In November 2021, the UK Government published a joint interim statement advising to use low noise alternatives to high order detonations where possible and it is anticipated that future developments will follow this guidance (JNCC, 2021c, UK Government *et al.*, 2022).

847. For the Array alone, with measures adopted as part of the Array applied there was predicted to be a small residual effect of PTS based on accidental high order detonation of UXOs. Within the EIA Report (volume 2, chapter 10), the residual magnitude for all species, except for harbour porpoise, was determined to be low. For harbour porpoise, it is expected that small, nominal number of animals could be exposed to PTS threshold (Table 6.69). Given that details about the UXO clearance technique to be used and charge sizes will not be available until after the consent is granted and are currently derived from desk-based study used to develop an MDS for this impact (Ordtek (2022)), it is not appropriate to quantify the effects of UXO detonations which are subject to change, and therefore summing the residual number of animals at multiple projects (prior to secondary mitigation) is not presented within this in-combination assessment. At a later stage, when details about the exact UXO sizes and specific clearance techniques to be used become available following detailed site investigation surveys, it will be possible to tailor the secondary mitigation to specific UXO sizes and species in order to reduce the risk of injury. Therefore, prior to the commencement of UXO clearance works, an EPS licence will be sought as required based on the further detailed information on UXOs available at the time, following site investigation surveys, and with the application of appropriate secondary mitigation measures as a part of the final MMMP (with an outline MMMP given in volume 4, appendix 22 of the Array EIA Report). It is therefore anticipated that following the application of secondary mitigation, the residual potential for potential impact will be reduced to low, and no adverse effect on the integrity of the SACs is predicted.

848. The assessment for Berwick Bank Offshore Wind Farm determined harbour porpoise were likely to be the most sensitive species to potential injury from high order UXO clearance. The EIA found that the maximum injury (PTS) range estimated for harbour porpoise using the $SPL_{pk}$ metric is 10,630 m for the high order detonation of charge size of 300 kg. Conservatively, the number of harbour porpoise that could be potentially injured during each high order detonation of UXO was up to 293 individuals (0.08% of the North Sea MU population and 0.76% of SCANS III Block R). Using the $SEL_{cum}$ metric, the predicted number of animals potentially affected was 38 animals. In the assessment, up to 16 grey seals had the potential to be injured during each high order detonation of the UXO (0.04% of the East Scotland plus Northeast England SMUs). Less than one bottlenose dolphin had the potential to be injured (SSE Renewables, 2022c) (Table 6.69).

849. The Berwick Bank Wind Farm EIA (SSE Renewables, 2022c) detailed designed in measures will be adopted as part of a MMMP to reduce the potential of experiencing injury. However, the mitigation zones required of 10 km are considerably larger than the standard 1,000 m mitigation zone recommended for UXO clearance (JNCC, 2010a). Visual surveys note that there is often a significant decline in detection rate with increasing sea state (Embling *et al.*, 2010, Leaper *et al.*, 2015). Therefore, the EIA details additional mitigation will be applied in the form of soft start charges and ADDs to reduce residual risk of injury. The assessment therefore determined that with the application of secondary mitigation measures (upon receipt of more detail regarding size and number of UXO post-consent as part of the EPS licence supporting information for UXO clearance), the magnitude of this potential impact will be reduced to low. Therefore, Berwick Bank EIA assessed the residual effect of auditory injury as minor adverse, with the residual magnitude as low following application of secondary measures (the unmitigated magnitude was medium based upon high order UXO clearance).

Table 6.69: **Number of Animals with the Potential to Experience PTS During UXO Clearance at Tier 1 Projects Prior to any Mitigation, and Residual Magnitude assessed in the EIA**

| Project | Species | Estimated Number of Animals in Impact Area (unmitigated) | Based upon UXO Size (kg) | Measures adopted | Residual Magnitude Assessed in EIA |
|---|---|---|---|---|---|
| Ossian Array | Harbour porpoise | 433 | 698 | Low order clearance as the intended methodology and an MMMP (volume 4, appendix 22 of the Array EIA Report) (ADD, soft start charges)[1] | Low |
| | Bottlenose dolphin | <1 | | | Negligible |
| | Grey seal | 5 | | | Negligible |
| Berwick Bank | Harbour porpoise | 293 (based on $SPL_{pk}$) | 300 | Low order clearance as the intended methodology and an MMMP (ADD, soft start charges) [1] | Low |
| | Bottlenose dolphin | <1 | | | Negligible |
| | Grey seal | 16 (based on $SPL_{pk}$) | | | Negligible |

[1] Detailed mitigation to be agreed post-consent to fully mitigate injury.

850. Although development of the Proposed offshore export cable corridor(s) will also be undertaken by the Applicant, route optioneering work is ongoing and so UXO surveys have not yet been completed. Therefore, there is currently no information by which to determine if UXO is scoped in or out of the impact assessment. Furthermore, there is uncertainty of the final design and location details of the Proposed offshore export cable corridor(s) and therefore it is not possible to provide any sort of quantitative assessment of UXO clearance. It can be reasonably assumed, however, that the extent of the impacts for the Proposed offshore export cable corridor(s) are expected to be of a similar extent than those represented by the MDS for the Array alone, since 698 kg represents a large munition size for the North Sea (section 6.3.2).

851. UXO clearance at each of these Tier 1 projects will occur as a discrete stage within the overall construction phase and therefore will not coincide continuously over the duration of temporal overlap. Furthermore, each clearance event results in a very short duration of sound emission (seconds) so the impact will be short in duration and therefore the overlap is unlikely. For example, whilst there is uncertainty in the final grid connection design and location details of the Proposed offshore export cable corridor(s), the Proposed offshore export cable corridor(s) is predicted to begin construction one year prior to the Array construction phase (Table 6.57), and therefore there will be no overlap in UXO clearance.

852. Given that the risk of injury will be reduced by the appropriate standard industry measures at respective projects to reduce the risk of PTS to marine mammals, the in-combination risk of injury is expected to be reduced further. At the Array with designed-in measures applied (Table 6.19), it is anticipated that all species except harbour porpoise would be deterred from the injury zone and therefore the likelihood of PTS and population-level effects would be unlikely. However, following the application of secondary mitigation as described in paragraph 580 *et seq*. and more detail regarding size and number of UXO, the risk of in-combination impact is considered to be low, as a reduction in potential impact to a non-significant level will reduce the Array's contribution to any in-combination impact on harbour porpoise in the North Sea MU (i.e., the in-combination assessment takes into account the Array alone commitments to reducing the potential for significant auditory injury to a non-significant level). Therefore, with the residual magnitude for harbour porpoise for both the Array alone and Berwick Bank Wind Farm as low in their respective EIA Reports, and the residual magnitude for other marine mammal receptors as negligible, it is anticipated that the in-combination impact will be reduced to a non-significant level for all species assessed in this Part of the RIAA.

**Behavioural disturbance (TTS as proxy)**

853. For this impact, TTS is applied as a proxy for strong disturbance (although noting that TTS onset could potentially result in a temporary loss in hearing). Whilst some behaviours (e.g. feeding, communication, socialisation) could be inhibited in the short term due to disruptions in ecological function (including a temporary hearing shift), these are reversible and therefore not considered likely to lead to any long-term effects on the individual. As discussed in paragraph 560, the duration of effect for each UXO detonation is less than one second and therefore behavioural effects are considered to be negligible in this context.

854. For Berwick Bank Wind Fam, the maximum range across which animals have the potential to experience disturbance (using TTS as a proxy) due to high order detonation of a 300 kg charge (as the MDS) was assessed for harbour porpoise as approximately 19 km. The disturbance ranges for bottlenose dolphin and grey seal are relatively small with a maximum of approximately 1 km and 6 km, respectively (SSE Renewables, 2022c).

855. Production of underwater noise during detonation of UXOs as a part of the in-combination projects as well as the Array have the potential to cause disturbance (TTS) in marine mammal receptors, however, this effect will be very short-lived (during detonation only) and reversible. A spatial MDS would occur where UXO clearance activities occur concurrently at the respective projects considered in the in-combination assessment. Sequential UXO clearance at respective projects could lead to a longer duration of effect. However, as described in paragraph 851, each clearance event results in a very short duration of noise emission (seconds) so the potential impact will be short in duration and therefore the overlap is unlikely, particularly given the construction phases of the Tier 1 projects are likely to be completed several years before the construction phase of the Array begins (i.e. due to safety reasons, UXO clearance activities takes place before other construction activities commence (JNCC, 2023a)).

856. Since each clearance event results in no more than a one second ensonification event and since animals are anticipated to recover quickly, the potential for in-combination effects with respect to disturbance is considered to be very limited. Furthermore, Berwick Bank Wind Farm lies over ~50 km away from the Array and therefore (given the maximum effect range was modelled as 19 km for harbour porpoise in the Berwick Bank EIA) it is unlikely to lead to in-combination behavioural effects.

857. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 1 projects. Based on this, it is concluded that in-combination UXO clearance at the Array and the Tier 1 projects will not have an adverse effect on the integrity of the marine mammal features of the SACs assessed in this Part of the RIAA.

Tier 2

858. There were four Tier 2 projects identified in the 100 km buffer of the Array with potential for in-combination effects associated with this impact:

- Cenos Offshore Wind Farm;
- Morven Offshore Wind Farm;
- Muir Mhor Offshore Wind Farm; and
- Salamander Offshore Wind Farm (Table 6.67).

859. The Cenos Offshore Wind Farm (Flotation Energy, 2023) included removal of UXO in construction impacts and stated if UXO is found, an underwater noise assessment specific to the UXO (the current presence and and characteristics of UXO cannot be predicted) found will be completed to inform mitigation and EPS application. The dates of construction at Cenos Offshore Wind Farm are unknown, but potential

overlap is unlikely given the short timescales of UXO clearance, and in combination with the distance from the Array (approximately 91.70 km) means that there is minimal spatial overlap from PTS and behavioural disturbance ranges and therefore potential for in-combiantion effects are unlikely.

860. The Morven Offshore Wind Farm scoped in injury and disturbance from UXO clearance in its Scoping Report (Morven Offshore Wind Limited, 2023). The Scoping Report detailed that a range of UXO sizes and clearance methodologies will be explored to develop the MDS (e.g. largest and most likely size/type of UXO, number of possible UXOs requiring clearance, high order vs low order/low yield clearance methodologies). The Morven construction phase has been assumed from 2031 to 2038, and therefore overlaps fully with that of the Array (Table 6.57).

861. The EIA Scoping Report for Muir Mhor Offshore Wind Farm (Fred Olsen Seawind *et al.*, 2023) proposed that noise related impacts associated with construction activities resulting in auditory injury (i.e. PTS) and behavioural disturbance are scoped into the EIA, and included UXO clearance. The impact assessment of the risk of auditory injury scoped in as a result of UXO clearance operations will include an assessment for both high order detonations and low order detonations, whilst aligning with recent recommendations and position statements on UXO clearance for similar offshore wind farm developments in the area. Construction at Muir Mhor Offshore Wind Farm is planned from 2027 to 2030, and any UXO clearance is likely to be undertaken prior to the construction phase, therefore it is unlikely there will be overlap of UXO clearance with the Array as it will be carried out prior to the Array construction phase. This, along with the distance from the site boundary (approximately 51.38 km) means that there is minimal spatial overlap from PTS and behavioural disturbance ranges and therefore potential for in-combination effects are unlikely.

862. The EIA Scoping Report for Salamander Offshore Wind Farm (Simply Blue Energy (Scotland) Limited, 2023) stated while UXO clearance will be subject to a separate Marine Licence application, an indicative assessment of the potential for noise impacts to marine mammals from UXO clearance during the construction phase will be included in the EIA, and therefore scoped in UXO clearance. The underwater noise assessment will likely include a quantitative assessment of the risk of injury and disturbance (using TTS-onset as a proxy) to all species scoped-in as a result of UXO clearance operations, based on indicative example UXO sizes supported by noise propagation modelling. The Salamander Offshore Wind Farm Scoping Report states the MMMP will be implemented for UXO clearance if needed. The dates of construction at Salamander Offshore Wind Farm are unknown, but potential overlap is unlikely given the short timescales of UXO clearance, and in combination with the distance from the Array (approximately 79.49 km) means potential for in-combination effects are unlikely.

863. It is expected that given that the risk of injury will be reduced by standard industry measures (including visual and acoustic monitoring) at respective projects, the in-combination risk of injury is expected to be reduced further. As discussed in paragraph 852 for the Tier 1 assessment, the in-combination assessment considers the Array's commitments to reducing any potential significant auditory injury to a non-significant level by implementation of designed in measures described in Table 6.19 (i.e. soft starts to UXO clearance, deployment of ADDs up to 30 mins prior to commencement of UXO clearance, application of low-order deflagration of UXO (where practicable) and implementation of a MMMP) and secondary mitigation measures discussed in paragraphs 580 *et seq.* (i.e. deployment of ADDs beyond 30 mins for prior to UXO clearance).

864. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 2 projects. Based on this, it is concluded that in-combination UXO clearance at the Array and the Tier 2 projects will not have an adverse effect on the integrity of the marine mammal features of the SACs assessed in this Part of the RIAA.

Tier 3

865. There were seven Tier 3 projects identified in the 100 km buffer with potential for in-combination effects associated with this impact:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm;
- Flora Floating Wind Farm;
- Aspen Offshore Wind Farm;
- Cedar Offshore Wind Farm; and
- Morven Offshore Export Cable Corridor(s) (Table 6.67).

866. The construction of the Array, together with construction phase of Tier 1, Tier 2 and Tier 3 projects may lead to in-combination injury and disturbance to marine mammals from underwater noise generated during UXO clearance.

867. As described in paragraph 795, the data in relation to Tier 3 projects available at the time of writing is limited, this is particularly the case for INTOG projects which as a new concept very little is known about the scale of the potential environmental impacts associated with these projects. Tier 3 projects were screened in precautionarily based on their location within 100 km of the site boundary within the regional marine mammal study area (noting this is a highly precautionary screening area for UXO clearance), though there is limited/no information on the construction/operation dates or project design with regards to UXO clearance. It should be acknowledged that there is a potential for UXO clearance activities to be taking place at these Tier 3 projects, and therefore in-combination effects cannot be discounted. However, at this point in time, is not possible to undertake a detailed quantitative assessment for potential in-combination impacts as a result of underwater noise generated during UXO clearance from the Array and other Tier 3 projects. There is no publicly available UXO clearance parameters or published assessments for Tier 3 projects (which are at pre-scoping stage), however given the phase of development there is likely to be no temporal overlap with the Array. Furthermore, given the maximum un-mitigated UXO ranges from the Array (maximum PTS range of 14.5 km, 26.7 km for TTS) there is low likelihood of any spatial overlap of ranges between the Array and Campion, Flora Floating Wind Farm, Aspen and Cedar. Therefore there is limited potential for an in-combination impact, and each project will have to implement their own UXO mitigation to limit injury and disturbance, thus further reducing the potential for in-combination effects of UXO clearance.

868. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 3 projects. Based on this, it is concluded that in-combination UXO clearance at the Array and the Tier 3 projects will not have an adverse effect on the integrity of the marine mammal features of the SACs assessed in this Part of the RIAA.

### Construction phase

Berwickshire and North Northumberland Coast SAC

**Grey seal**

*Tier 1*

869. Of the two Tier 1 projects identified, only Berwick Bank has a publicly available EIA Report and RIAA (SSE Renewables, 2022c, SSE Renewables, 2022e). The RIAA concluded that effects caused by UXO clearance are considered unlikely to cause a change in reproduction and survival rates or alteration in the distribution of the population of grey seal from the Berwickshire and North Northumberland Coast SAC (SSE Renewables, 2022e). Given that this effect is short in duration, connectivity with important habitats within and outside the site is also unlikely to be impaired. Considering the number of animals potentially affected by PTS and TTS, respective proportions of the SAC population potentially affected and designed in measures reducing the risk of adverse effects, it was concluded highly unlikely that UXO clearance would influence grey seal of Berwickshire and North Northumberland population trajectory in the long-term (SSE Renewables, 2022e).

870. The Tier 1 assessment, presented in paragraphs 841 *et seq.,* concluded that injury and disturbance as a result of underwater noise from in-combination UXO clearance in the construction phase are unlikely to occur. Given that the risk of injury will be reduced by the appropriate standard industry measures at respective projects to reduce the risk of PTS to marine mammals, the in-combination risk of injury is expected to be reduced further. At the Array alone, with designed-in measures applied (Table 6.19), it is anticipated that grey seal would be deterred from the injury zone and therefore the likelihood of PTS and population-level effects would be unlikely. As per the assessment of the Array alone (section 6.3.2), it is also expected that grey seals would move beyond the injury range, thereby reducing the risk of PTS. Grey seals are likely to be able to tolerate the in-combination behavioural disturbance without any risk to the populations (such as by fleeing the affected area), reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased.

*Tier 2*

871. The Tier 2 assessment, presented in paragraphs 858 *et seq.,* concluded that in-combination effects as a result of underwater noise from UXO clearance in the construction phase are unlikely to occur. It is expected that the risk of injury will be reduced by standard industry measures (including visual and acoustic monitoring) at respective projects. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 2 projects. Based on this, it is concluded that in-combination UXO clearance at the Array and the Tier 2 projects will not have an adverse effect on the integrity of the grey seal feature of this SAC.

*Tier 3*

872. The Tier 3 assessment, presented in paragraphs 865 *et seq.,* highlighted that it was not possible to confirm with any degree of certainty whether there would be overlap in UXO clearance with Ossian construction activities and the nine Tier 3 projects identified for this impact. This was due to the lack of publicly available information surrounding piling parameters and lack of knowledge in general about INTOG projects. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 3 .

873. There is no publicly available UXO clearance parameters or published assessments for Tier 3 projects (which are at pre-scoping stage), however given the phase of development there is likely to be no temporal overlap with the Array. Furthermore, given the maximum un-mitigated UXO injury ranges for grey seal from the Array (maximum PTS range of 2,850 m, 6,120 m for TTS) there is low likelihood of any spatial overlap of ranges between the Array and Campion, Flora Floating Wind Farm, Aspen and Cedar. Therefore there is limited potential for an in-combination impact, and each project will have to implement their own UXO mitigation to limit injury and disturbance, thus further reducing the potential for in-combination effects of UXO clearance.

874. Based on this, it is concluded that in-combination UXO clearance at the Array and the Tier 3 projects will not have an adverse effect on the integrity of the grey seal feature of this SAC.

*Conclusion*

875. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.1) are discussed in turn below in Table 6.70.

**Table 6.70: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Underwater Noise Generated During UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained<br>The structure and function of the habitats of the qualifying species are maintained<br>The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | There is no pathway for potential impact between in-combination underwater noise generated during UXO clearance and the extent, distribution, structure and function of habitats and supporting processes of grey seal. Therefore, the the extent, distribution, structure and function of habitats and supporting processes of grey seal will not be adversely affected by this potential impact associated with the Array in-combination with the Tier 1, 2, and 3 projects. |
| | The populations of each of the qualifying species are maintained<br>The distribution of qualifying species within the site are maintained | Overall, underwater noise from UXO clearance in-combination with the Array and the other projects is unlikely to lead to injury or strong behavioural responses. The in-combination assessment has concluded that this potential impact is highly unlikely to disrupt the population or distribution of grey seal associated with this SAC. Published injury and disturbance ranges were only available for the Berwick Bank Offshore Wind Farm (Tier 1), where up to 16 grey seals were estimated as having the potential to experience PTS (Table 6.69). With the addition of the five grey seals predicted to experience PTS associated with the Array (Table 6.69), a significant proportion of this SAC population is not anticipated to be affected. As such, and with the consideration of designed in measures, it is likely that individuals would be able to flee the potential ZoI and reduce any potential for in-combination impact. Therefore, the populations and distribution of grey seal within this SAC are not likely to be impacted by injury (PTS) associated with UXO clearance, particularly at a population level.<br><br>Strong behavioural disturbance impacts (using TTS as a proxy) are predicted to be very short term and reversible, as impacted grey seal are anticipated to fully recover. The assessment considered that grey seal is likely to be able to tolerate strong behavioural disturbance from in-combination projects without any potential impact on either reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased. Therefore, injury and disturbance from underwater noise generated during UXO clearance from the Array in-combination with other plans and projects is not predicted to prevent the population or distribution of grey seal within the site from being maintained. |

876. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of underwater noise generated during UXO clearance in the construction phase of the Array in-combination with other plans and projects.

Southern North Sea SAC

**Harbour porpoise**

*Tier 1*

877. Of the two Tier 1 projects identified, only Berwick Bank has a publicly available EIA Report and RIAA (SSE Renewables, 2022c, SSE Renewables, 2022e). The RIAA concluded that effects caused by UXO clearance are considered unlikely to cause a change in reproduction and survival rates or alteration in the distribution of the population of harbour porpoise from the Southern North Sea SAC (SSE Renewables, 2022e). UXO clearance activities associated with Berwick Bank will not take place within or nearby to the Southern North Sea SAC (146 km south from Berwick Bank), and therefore will not exclude harbour porpoise from the relevant area of the site (SSE Renewables, 2022e). The Berwick Bank RIAA concluded that behavioural disturbance as a result of UXO clearance is unlikely to alter the distribution of harbour porpoise such that recovery cannot be expected or that effects on Southern North Sea SAC population could be considered long term (SSE Renewables, 2022e). Additionally, since there was no potential for modelled injury ranges or disturbance contours associated with Berwick Bank to reach the SAC, it will not affect foraging habitats and areas important for breeding and calving within the SAC (SSE Renewables, 2022e).

878. The Tier 1 assessment, presented in paragraphs 841 *et seq.,* concluded that injury and disturbance as a result of in-combination UXO clearance in the construction phase are unlikely to occur. Given that the risk of injury will be reduced by the appropriate standard industry measures at respective projects to reduce the risk of PTS to marine mammals, the in-combination risk of injury is expected to be reduced further. At the Array alone, with designed-in measures applied (Table 6.19), it is anticipated that all species except harbour porpoise would be deterred from the injury zone and therefore the likelihood of PTS and population-level effects would be unlikely. However, following the application of secondary mitigation tailored to take account of the size and number of UXO following further site-specific survey work (paragraph 580), the risk of in-combination impact is considered to be low. Therefore application of secondary mitigation will reduce the Array's contribution to any in-combination impact resulting from auditory injury on harbour porpoise in the North Sea MU to a non-significant level (i.e., the in-combination assessment takes into account the Array alone commitments (see paragraphs 580 *et seq.*). Therefore, with the residual magnitude for harbour porpoise for both the Array alone and Berwick Bank Wind Farm as low in their respective EIA Reports, it is anticipated that the in-combination impact will be reduced to a non-significant level. Considering that only up to 29 UXOs cumulatively from Tier 1 projects (Table 6.68) require clearing and with low order techniques being prioritised, it is expected that UXO clearance would not manifest to population-level effects due to the small proportion of the North Sea MU potentially affected.

879. As undertaken for the assessment of the Array alone, the EDR approach has also been used for the assessment of disturbance associated with UXO clearance during the construction phase for harbour porpoise features in-combination with other plans and projects. Only two in-combination projects were relevant for inclusion: Berwick Bank Wind Farm (Tier 1) and Morven Offshore Wind Farm (Tier 2). This is based on their proximity to the site boundary and public availability of their potential UXO parameters. Although there are some Tier 3 projects in close proximity to the site boundary (such as Bellrock and Bowdun Offshore Wind Farms), there are no publicly available documents, and the construction schedules are still unknown, so it is not possible to confirm with any degree of certainty whether there would be overlap in UXO clearance with Ossian construction activities. As per the JNCC (2020) guidance, 26 km EDRs have been plotted for Berwick Bank Wind Farm and Morven Offshore Wind Farm (Figure 6.15) to assess the potential for in-combination disturbance to the Southern North Sea SAC. It should be noted that as individual UXO locations are not currently available for these projects (or for the Array), and so the 26 km EDRs have been drawn from the southernmost tip of respective project boundaries, which would be the closest possible location to the Southern North Sea SAC. Therefore, these EDRs may be over precautionary as UXO detonations may be concentrated further away from the SAC. Given that there is no overlap between these EDRs and the Southern North Sea SAC (Figure 6.15), the conclusion that there will not be an in-combination impact to this SAC is further supported.

*Tier 2*

880. The Tier 2 assessment, presented in paragraphs 858 *et seq.,* concluded that in-combination effects as a result of UXO clearance in the construction phase are unlikely to occur. It is expected that the risk of injury will be reduced by standard industry measures (including visual and acoustic monitoring) at respective projects. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 2 projects. Based on this, it is concluded that in-combination UXO clearance at the Array and the Tier 2 projects will not have an adverse effect on the integrity of the harbour porpoise feature of this SAC.

*Tier 3*

881. The Tier 3 assessment, presented in paragraphs 865 *et seq.,* highlighted that it was not possible to confirm with any degree of certainty whether there would be overlap in UXO clearance with Ossian construction activities and the nine Tier 3 projects identified for this impact. This was due to the lack of publicly available information surrounding piling parameters and lack of knowledge in general about INTOG projects. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 3 projects.

882. There is no publicly available UXO clearance parameters or published assessments for Tier 3 projects (which are at pre-scoping stage), however given the phase of development there is likely to be no temporal overlap with the Array. Furthermore, given the maximum un-mitigated UXO injury ranges for harbour porpoise from the Array (maximum PTS range of 14.5 km, 26.7 km for TTS) there is low likelihood of any spatial overlap of ranges between the Array and Campion, Flora Floating Wind Farm, Aspen and Cedar. Therefore, there is limited potential for an in-combination impact, and each project will have to implement their own UXO mitigation to limit injury and disturbance, thus further reducing the potential for in-combination effects of UXO clearance.

883. Based on this, it is concluded that in-combination UXO clearance at the Array and the Tier 3 projects will not have an adverse effect on the integrity of the harbour porpoise feature of this SAC.

*Conclusion*

884. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.71.

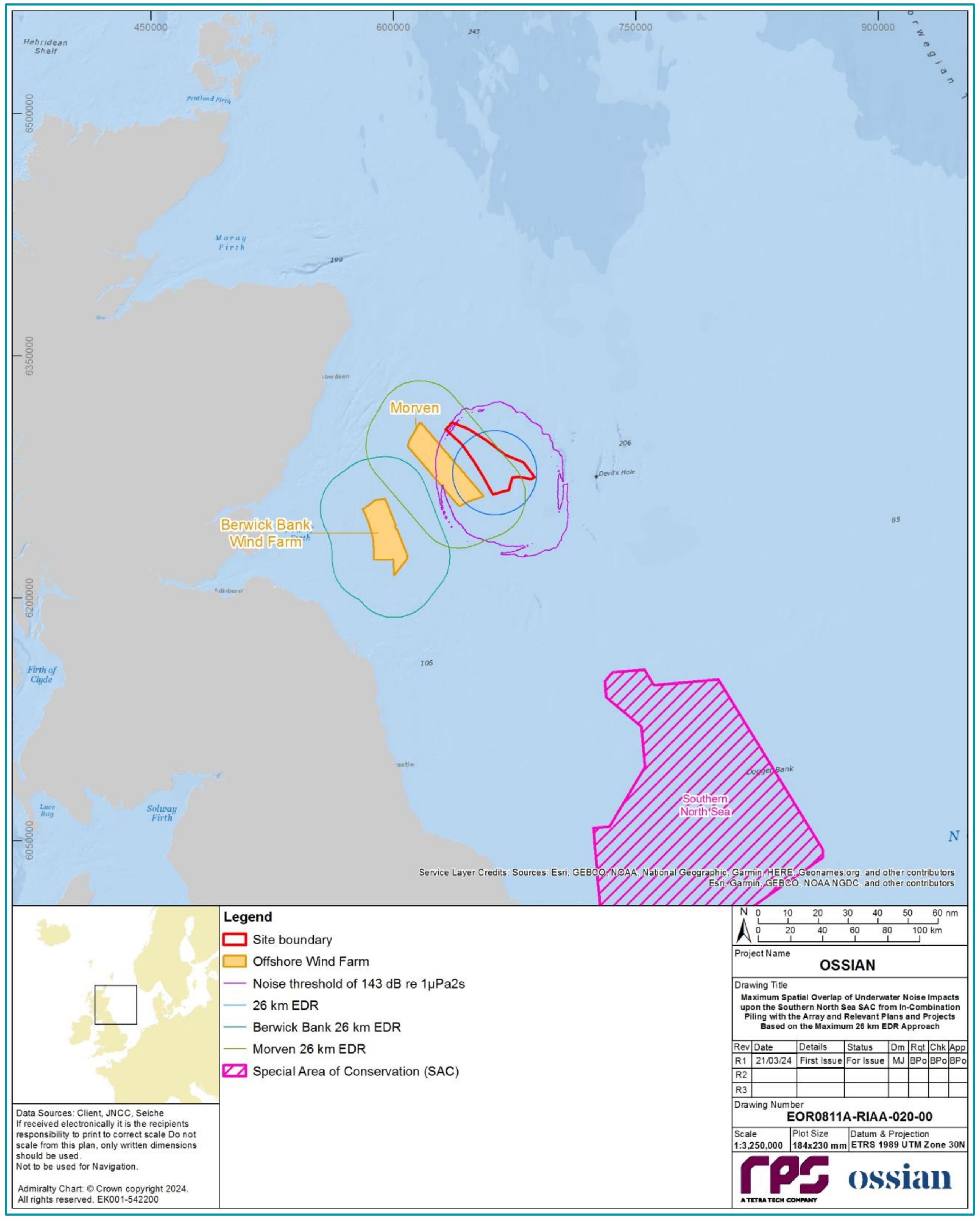


**Figure 6.15: Maximum Spatial Overlap of Underwater Noise Impacts upon the Southern North Sea SAC from In-Combination UXO Clearance with the Array and Relevant Plans and Projects Based on the 26 km EDR Approach**

**Table 6.71: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Underwater Noise Generated During UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects.**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site | Overall, underwater noise from in-combination UXO clearance may lead to injury or strong behavioural responses in a small proportion of the North Sea MU population of harbour porpoise. For the Array alone, the maximum injury (in terms of PTS) range estimated for harbour porpoise was 14,540 m using the $SPL_{pk}$ metric for a high order detonation of 698 kg NEQ. At this range, up to 433 animals may experience PTS (Table 6.69), which equates to less than 0.12% of the population of the North Sea MU. However, it should be noted that this will be mitigated as outlined in Table 6.19, and therefore this risk is reduced. The only project with publicly available EIA or RIAA documentation was Berwick Bank Offshore Wind Farm (Tier 1). Its EIA found that the maximum injury (PTS) range estimated for harbour porpoise using the $SPL_{pk}$ metric was 10,630 m for the high order detonation of charge size of 300 kg (SSE Renewables, 2022c). Conservatively, the number of harbour porpoise that could be potentially injured during each high order detonation of UXO was up to 293 individuals (0.08% of the North Sea MU population; Table 6.69). Again, this will be mitigated by the measures outlined in Table 6.19 and the risk therefore reduced.<br><br>Following the implementation of designed in and secondary mitigation measures, the in-combination assessment concluded that this potential impact is unlikely to disrupt the population of harbour porpoise associated with this SAC. In addition, the maximum range of strong behavioural disturbance (using TTS as a proxy) was modelled out to 26,790 m for the Array and approximately 19 km for Berwick Bank (SSE Renewables, 2022c). These ranges are similar to the 26 km EDR for UXO clearance recommended in the JNCC (2020) guidance, which was assessed for the Array, Berwick Bank, and Morven (Tier 2) (Figure 6.15). These ranges do not extend to the SAC and therefore animals are unlikely to experience significant disturbance within the site. Underwater noise from in-combination UXO clearance will therefore not affect areas important for breeding and calving within the SAC, and therefore harbour porpoise will remain a viable component of the site. Overall, following designed in and secondary mitigation measures, underwater noise generated during UXO clearance at the Array and the Tier 1, 2, and 3 projects is not predicted to impact the population from being able to maintain itself as a viable component of the site over the long term. |
| | 2. There is no significant disturbance of the species | As noted in the row above, strong behavioural disturbance (using TTS as a proxy) was modelled out to 26,790 m for the Array and approximately 19 km for Berwick Bank (SSE Renewables, 2022c). These values were in line with the 26 km EDR recommended for UXO clearance in the JNCC (2020) guidance (Figure 6.15). Given that these ranges do not extend to the site (which is 129.86 km away), it is anticipated that there will be no significant disturbance to the harbour porpoise feature of the site as a result of this potential impact in-combination with other plans and projects. |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for potential impact between in-combination underwater noise generated during UXO clearance and the habitats and supporting processes of harbour porpoise. With respect to the availability of prey, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.4.5), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support harbour porpoise will not be adversely affected by this potential impact associated with the Array in-combination with the Tier 1, 2, and 3 projects. |

885. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of underwater noise generated during UXO clearance in the construction phase of the Array in-combination with other plans and projects.

Moray Firth SAC

**Bottlenose dolphin**

*Tier 1*

886. Of the two Tier 1 projects identified, only Berwick Bank has a publicly available EIA Report and RIAA (SSE Renewables, 2022c, SSE Renewables, 2022e). The Berwick Bank RIAA concluded that the TTS ranges do not extend to the Moray Firth SAC and only small number of animals may experience TTS within the Coastal East Scotland MU. Therefore disturbance will not be significant (SSE Renewables, 2022e). The Berwick Bank RIAA concluded will be no disturbance with areas used by dependant mothers and calves, therefore it is highly unlikely that the reproductive and recruitment capability of the species will be affected (SSE Renewables, 2022e).

887. The Tier 1 assessment, presented in paragraphs 841 *et seq.,* concluded that injury and disturbance as a result of in-combination UXO clearance in the construction phase are unlikely to occur. Given that the risk of injury will be reduced by the appropriate standard industry measures at respective projects to reduce the risk of PTS to marine mammals, the in-combination risk of injury is expected to be reduced further. At the Array alone, with designed-in measures applied (Table 6.19), it is anticipated that bottlenose dolphin would be deterred from the injury zone and therefore the likelihood of PTS and population-level effects would be unlikely. As per the assessment of the Array alone (section 6.3.2), it is also expected that bottlenose dolphins would move beyond the injury range. Bottlenose dolphins are likely to be able to tolerate the in-combination effect without any potential impact on either reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased.

*Tier 2*

888. The Tier 2 assessment, presented in paragraphs 858 *et seq.,* concluded that in-combination effects as a result of UXO clearance in the construction phase are unlikely to occur. It is expected that the risk of injury will be reduced by standard industry measures (including visual and acoustic monitoring) at respective projects. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 2 projects. Based on this, it is concluded that in-combination UXO clearance at the Array and the Tier 2 projects will not have an adverse effect on the integrity of the bottlenose dolphin feature of this SAC.

*Tier 3*

889. The Tier 3 assessment, presented in paragraphs 865 *et seq.,* highlighted that it was not possible to confirm with any degree of certainty whether there would be overlap in UXO clearance with Ossian construction activities and the nine Tier 3 projects identified for this impact. This was due to the lack of publicly available information surrounding piling parameters and lack of knowledge in general about INTOG projects. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 3 projects.

890. There is no publicly available UXO clearance parameters or published assessments for Tier 3 projects (which are at pre-scoping stage), however given the phase of development there is likely to be no temporal overlap with the Array. Furthermore, given the maximum un-mitigated UXO injury ranges for bottlenose dolphin from the Array (maximum PTS range of 840 m, 1,550 m for TTS) there is low likelihood of any spatial overlap of ranges between the Array and Campion, Flora Floating Wind Farm, Aspen and Cedar. Therefore, there is limited potential for an in-combination impact, and each project will have to implement their own UXO mitigation to limit injury and disturbance, thus further reducing the potential for in-combination effects of UXO clearance.

891. Based on this, it is concluded that in-combination UXO clearance at the Array and the Tier 3 projects will not have an adverse effect on the integrity of the bottlenose dolphin feature of this SAC.

*Conclusion*

892. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination underwater noise generated during UXO clearance in the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.72.

**Table 6.72: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Underwater Noise Generated During UXO Clearance in the Construction Phase of the Array In-Combination with other Plans and Projects.**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site | Overall, elevated underwater noise from UXO clearance is unlikely to lead to injury or strong behavioural responses to bottlenose dolphin. The assessment of the Array alone has concluded that this potential impact is highly unlikely to disrupt the population of bottlenose dolphin associated with this SAC. The maximum injury (in terms of PTS) range estimated for bottlenose dolphin was 840 m using the $SPL_{pk}$ metric for a high order detonation of 698 kg NEQ. At this range, no more than one bottlenose dolphin may experience PTS (Table 6.69) which equates to less than 0.01% of the population of the Coastal East Scotland MU. The only project with publicly available EIA or RIAA documentation was Berwick Bank Offshore Wind Farm (Tier 1). The Berwick Bank EIA also found that no more than one bottlenose dolphin could experience PTS as a result of UXO clearance (Table 6.69) (SSE Renewables, 2022c). Including the implementation of designed in mitigation measures and distance of the Array from the coastal MU population, the in-combination assessment concluded that this potential impact is unlikely to disrupt the population of bottlenose dolphin associated with this SAC.<br><br>In addition, the maximum range of strong behavioural disturbance (using TTS as a proxy) was modelled out to 1,550 m for the Array and approximately 1,000 m for Berwick Bank (SSE Renewables, 2022c). These ranges do not extend to the SAC and therefore animals are unlikely to experience significant disturbance within the site. In-combination UXO clearance will therefore not affect areas important for breeding and calving within the SAC, and therefore bottlenose dolphin will remain a viable component of the site. Overall, underwater noise generated during UXO clearance at the Array and the Tier 1, 2, and 3 projects is not predicted to impact the population from being able to maintain itself as a viable component of the site over the long term. |
| | 2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance | As noted in the row above, strong behavioural disturbance (using TTS as a proxy) was modelled out to 1,550 m for the Array and approximately 1,000 m for Berwick Bank (SSE Renewables, 2022c). Given that these ranges do not extend to the site (175.86 km away), it is anticipated that significant disturbance of the bottlenose dolphin feature of the site will be avoided. Therefore, disturbance due to in-combination underwater noise generated during UXO clearance is not predicted to impact the distribution of bottlenose dolphin throughout the site. |
| | 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained | There is no pathway for potential impact between in-combination underwater noise generated during UXO clearance and the habitats and supporting processes of bottlenose dolphin. With respect to the availability of prey, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.4.5), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support bottlenose dolphin will not be adversely affected by this potential impact associated with the Array in-combination with the Tier 1, 2, and 3 projects. |

893. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of underwater noise generated during UXO clearance in the construction phase of the Array in-combination with other plans and projects.

### 6.4.4. DISTURBANCE DUE TO SITE-INVESTIGATION SURVEYS (INCLUDING GEOPHYSICAL SURVEYS)

894. The LSE[2] assessment during the HRA Stage One process identified that LSE[2] could not be ruled out for disturbance due to site investigation surveys (including geophysical surveys) in the construction and operation and maintenance phases of the Array in-combination with other plans and projects. This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

895. The risk of injury in terms of PTS to marine mammal receptors as a result of underwater noise due to site-investigation surveys would be expected to be localised to within the boundaries of the respective projects. The assessment for the Array alone found that the maximum impact range was 310 m for geophysical surveys and 45 m for geotechnical surveys (based on harbour porpoise) and this highly localised, with numbers of animals impacted will be extremely low (section 6.3.3). Furthermore, any risk of injury will be mitigated via the MMMP (volume 4, appendix 22 of the Array EIA Report) and there will no potential for in-combination injury. The in-combination assessment provided in this section therefore focuses on disturbance only.

896. The MDS considered for this in-combination assessment is shown in Table 6.73. The designed in measures are presented in Table 6.33 for the assessment of the Array alone.

**Table 6.73: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Disturbance due to Site-Investigation Surveys in the Construction and Operation and Maintenance Phases of the Array In-Combination with other Plans and Projects**

| Project Phase | Tier | MDS |
|---|---|---|
| Construction and operation and maintenance phases | 1 | **Construction Phase**<br><br>MDS as described for the construction phase in Table 6.32, assessed cumulatively with construction of the following marine projects within the 50 km search buffer:<br>• Ossian Proposed offshore export cable corridor(s).<br><br>**Operation and Maintenance Phase**<br><br>MDS as described for the operation and maintenance phase in Table 6.32, assessed cumulatively with operational phase of the following marine projects within the 50 km search buffer:<br>• Proposed offshore export cable corridor(s). |
| | 2 | **Construction Phase**<br><br>MDS as described for the construction phase in Table 6.32,assessed cumulatively with construction of the following marine projects within the 50 km search buffer:<br>• Morven Offshore Wind Farm; and<br>• Tier 1 Projects.<br><br>Operation and Maintenance Phase<br><br>There are currently no known projects which will result in a cumulative effect during the operation and maintenance phase of the Array. |
| | 3 | Construction Phase<br><br>The MDS is as described above for the Array alone in Table 6.32, assessed in-combination with construction of the following projects within the 50 km search buffer:<br>• Bellrock Offshore Wind Farm;<br>• Bowdun Offshore Wind Farm;<br>• Campion Offshore Wind Farm;<br>• Morven Offshore Export Cable Corridor(s); and<br>• Tier 1 Projects and Tier 2 Projects.<br><br>Operation and Maintenance Phase<br><br>There are currently no known projects which will result in a cumulative effect during the operation and maintenance phase of the Array. |

### In-combination assessment

897. There is the potential for in-combination impacts from site-investigation surveys in the construction and operation and maintenance phases of the Array and other plans and projects. For the purposes of this assessment, this potential impact has been assessed using the tiered approach outlined in section 4.6. The plans and projects screened into the in-combination assessment for this potential impact and their respective tiers are outlined in Table 6.73.

Tier 1

898. One Tier 1 project was identified with potential for in-combination effects associated with this potential impact within the 50 km buffer, during the construction and operation and maintenance phases:

- Proposed offshore export cable corridor(s) (construction and operation and maintenance phases) (Table 6.73).

899. As discussed in section 4.6, there is uncertainty of the final design and location details of the Proposed offshore export cable corridor(s) and therefore it is not possible to provide a quantitative assessment of the in-combination impact from site-investigation surveys. It can be reasonably assumed the extent of the impacts for the Proposed offshore export cable corridor(s) are expected to be similar to those of the Array alone (see section 6.3.3), as, whilst the geographical location of the geophysical survey areas of other projects will differ, the extent of the disturbance per survey equipment at any one point will likely be very similar. The construction phase (and associated pre-construction surveys) of the Proposed offshore export cable corridor(s) (2030 to 2037) overlaps with that of the Array and therefore there is the potential for temporal overlap in site-investigation surveys. However, it should be noted that site-investigation survey equipment will not be operating continuously, it will be used when required for investigations of particular areas of the seabed where additional information is required to inform the construction. Site-investigation surveys for Proposed offshore export cable corridor(s) are likely to be carried out at the start of the construction phase (2030) and therefore direct overlap with the site-investigation surveys for the Array is unlikely (particularly given the need for limited resource to undertake site-investigation surveys).

900. For the Array alone, the maximum disturbance range across all geophysical surveys was estimated as 1,340 m (SBP) activity and the maximum range across geotechnical activities was 9,101 m (vibrocoring) for all species (see section 6.3.3). Given that the distance between the Array and the Proposed offshore export cable corridor(s) is less than the estimated disturbance ranges from geophysical surveys, there is potential for spatial overlap. However, the likelihood of temporal overlap of site investigation surveys at these projects is very low, and it is therefore unlikely, due to the temporal separation, that site-investigation surveys at the Array and Proposed offshore export cable corridor(s) will spatially overlap at any one time.

901. Site-investigation surveys are anticipated to be short term in nature (weeks to a few months) and occur intermittently over the construction phase. For example, the site-investigation surveys for the Array will be carried out over 5 months within a 3 year period.

902. This potential impact has also been considered for the operation and maintenance phase. For the Array, routine geophysical surveys will take place once every 24 months for wind turbines and OSP foundations as well as wind turbines interior and exterior. For inter-array cables and interconnector cables routine geophysical surveys will be undertaken annually for the first three years, then every 24 months. The duration of routine geophysical survey campaign is up to three months. It is possible that routine geophysical surveys for the Proposed offshore export cable corridor(s) will be similar to those of the inter-array cables and interconnector cables for the Array and therefore, there is potential for geophysical surveys during the operation and maintenance phase to temporally overlap with the Proposed offshore export cable corridor(s). As for the construction phase, surveys are anticipated to be short term in nature (weeks to a few months) and occur intermittently over the operation and maintenance phase.

903. For construction and operation and maintenance activities, it is likely that the Proposed offshore export cable corridor(s) will also include an MMMP as a designed in measure, similar to that adopted for the Array alone (Table 6.33). While this primarily mitigates against injury (which has not been assessed in-combination, see paragraph 895) it will also aid in reducing disturbance to marine mammals. In addition, this potential impact is of high reversibility, with animals returning to baseline levels shortly after surveys have ceased. As such, and in consideration of the potential designed in measure of an MMMP, population-level effects associated with this potential impact are unlikely for the marine mammal features of the SACs.

Tier 2

904. In addition to Tier 1 projects, one Tier 2 project was identified with potential for in-combination effects associated with this impact, which lies within the 50 km buffer used for site-investigation surveys:

- Morven Offshore Wind Farm (Table 6.73).

905. Disturbance to marine mammals from pre-construction site-investigation surveys is scoped in for Morven Offshore Wind Farm (Morven Offshore Wind Limited, 2023). The Scoping Report details comparative sound modelling for geophysical activities will be undertaken to inform an assessment of possible effects from elevated levels of underwater noise. At this point in time, there is not quantitative information upon which to take a more detailed assessment of site-investigation surveys. The site boundary lies, at the closest point, 5.5 km from the Morven Array and based on the maximum disturbance range predicted for the Array (9,101 m for vibrocoring for all species) there is potential for spatial overlap between these two projects for vibrocoring surveys. However, the likelihood of temporal overlap of site investigation surveys at the Array and Morven Offshore Wind Farm is very low (e.g. there are limitations on the number of survey vessels that could carry out such surveys at one time) and it is therefore unlikely, due to the temporal separation, that site-investigation surveys at Morven Offshore Wind Farm would overlap with the area disturbed during site-investigation surveys at the Tier 1 project, Proposed offshore export cable corridor(s) (see paragraph 631 for detail). Within the Morven Offshore Wind farm Scoping Report (Morven Offshore Wind Limited, 2023), this potential impact was not scoped in for the operation and maintenance phase, and has thus not been discussed further in this Tier 2 assessment.

906. For construction activities, it is likely that Morven Offshore Wind Farm will also include an MMMP as a designed in measure, similar to that adopted for the Array alone (Table 6.33). While this primarily mitigates against injury (which has not been assessed in-combination, see paragraph 895) it will also aid in reducing disturbance to marine mammals. In addition, behavioural disturbance is of high reversibility, with animals returning to baseline levels shortly after surveys have ceased. As such, and in consideration of the potential designed in measure of an MMMP, population-level effects associated with this potential impact are considered unlikely for the marine mammal features of the SACs.

Tier 3

907. Four Tier 3 projects were identified with potential for in-combination effects associated with this impact, which lie within the 50 km buffer used for site-investigation surveys:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm;
- Morven Offshore Export Cable Corridor(s) (Table 6.73).

908. Tier 3 projects are in a pre-application phase and no EIA Scoping Report, EIA Report, or HRA documentation are available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

909. Whilst there is no information on the timeline for construction at Bellrock Offshore Wind Farm and therefore it cannot be excluded from the in-combination assessment, the likelihood of direct temporal overlap with site-investigation surveys at Bellrock Offshore Wind Farm and the Array is unlikely given the different stages of status of development. Furthermore, surveys are likely to be short term and intermittent and disturbance ranges associated with these projects would be highly localised. Bellrock Offshore Wind Farm is located 8.57 km north-west from the Array and therefore site-investigation surveys will have no spatial overlap given the small disturbance ranges presented for the Array assessment (see section 6.3.3).

910. Whilst there is no information on the timeline for construction at Bowdun Offshore Wind Farm and therefore it cannot be excluded from the in-combination assessment, the likelihood of direct temporal overlap with site-investigation surveys at Bowdun Offshore Wind Farm and the Array is unlikely given the different stages of status of development. Furthermore, surveys are likely to be short term and intermittent and disturbance ranges associated with these projects would be highly localised. Bowdun Offshore Wind Farm is located 25.35 km north-west from the Array and therefore site-investigation surveys will have no spatial overlap given the small disturbance ranges presented for the Array assessment (see section 6.3.3).

911. The likelihood of direct temporal overlap with site-investigation surveys at Campion Offshore Wind and the Array is unlikely given the different stages of status of development. Furthermore, surveys are likely to be short term and intermittent and disturbance ranges associated with these projects would be highly localised. Campion Offshore Wind Farm is located 44.15 km north-east from the Array and therefore site-investigation surveys will have no spatial overlap given the small disturbance ranges presented for the Array assessment (see section 6.3.3).

912. Further, site-investigation surveys associated with the Morven Offshore Export Cable Corridor(s) are likely to occur during its construction phase, however it is unknown whether they will persist over the operation and maintenance phase, as is assumed for the Tier 3 offshore wind farm projects. It is likely that these surveys will be completed prior to those associated with the construction of the Array, however, overlap has been assumed as a precaution.

913. For site-investigation surveys, it is likely that Tier 3 projects will also include an MMMP as a designed in measure, similar to that adopted for the Array alone (Table 6.33). While this primarily mitigates against injury (which has not been carried forward for assessment in-combination, see paragraph 895) it will also aid in reducing disturbance to marine mammals. In addition, behavioural disturbance is of high reversibility, with animals returning to baseline levels shortly after surveys have ceased. As such, and in consideration of the potential designed in measure of an MMMP, population-level effects associated with this potential impact are unlikely for the marine mammal features of the SACs.

### Construction and operation and maintenance phases

Berwickshire and North Northumberland Coast SAC

**Grey seal**

*All Tiers*

914. There was no species or SAC specific information available for any of projects identified for in-combination effects for this impact, therefore all Tiers have been addressed here.

915. As detailed in paragraphs 898 *et seq.,* site-investigation surveys for the Tiers 1, 2, and 3 projects are expected to be short term in nature and occur intermittently. In addition, behavioural disturbance is of high reversibility, with animals returning to baseline levels shortly after surveys have ceased. As per the values modelled for the Array alone (section 6.3.3), disturbance ranges are likely to be within the metres to low kilometres depending on the survey technique. For the Array alone, the maximum disturbance range across all geophysical surveys was estimated as 1,340 m for SBP activity and the maximum range across geotechnical activities was 9,101 m for vibrocoring) for all species (see Table 6.37). Therefore, the potential for in-combination effects is reduced, particularly for projects that are tens of kilometres away from the site boundary (such as Bowdun and Campion Offshore Wind Farms in Tier 3). In-combination behavioural disturbance ranges are therefore highly unlikely to overlap with the Berwickshire and North Northumberland Coast SAC, which is a minimum of 113.95 km south-west from the site boundary.

916. For construction and operation and maintenance activities, it is likely that the Tier 1, 2, and 3 projects will also include an MMMP as a designed in measure, similar to that adopted for the Array alone (Table 6.33). As such, and in consideration of the potential designed in measure of an MMMP, population-level effects associated with this potential impact are unlikely for the grey seal feature of this SAC.

*Conclusion*

917. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination disturbance due to site-investigation surveys during the construction and operation and maintenance phases. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.1) are discussed in turn below in Table 6.74.

**Table 6.74: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Disturbance due to Site-Investigation Surveys (Including Geophysical Surveys) during the Construction and Operation and Maintenance Phases of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for potential impact between site-investigation surveys and the extent, distribution, structure, and function of the habitats and supporting processes of grey seal (i.e. no overlap with the area of significant disturbance with the SAC). Therefore, the extent, distribution, structure, and function of the habitats and supporting processes of grey seal will not be adversely affected by site-investigation surveys from the Array in-combination with the Tier 1, 2, and 3 projects. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | Overall, site-investigation surveys in the construction and operation and maintenance phases of the Array in-combination with other plans and projects are unlikely to lead to strong behavioural responses to grey seal. There were no disturbance ranges available for any of the Tier 1, 2, or 3 projects, however the maximum disturbance range modelled for the Array alone was 9,101 m for vibrocoring (Table 6.37). Given the scale and nature of the Tier 1, 2, and 3 projects (other offshore wind farms and a subsea transmission cable), disturbance ranges are likely to be similar to those modelled for the Array alone. Therefore, it is unlikely that disturbance ranges will extend to the SAC (113.95 km away) and therefore animals are unlikely to experience significant disturbance within the site. Site-investigation surveys will therefore not affect areas important for breeding and pupping within the SAC, and therefore grey seal will remain a viable component of the site. Overall, including the implementation of designed in mitigation measures, site-investigation surveys associated with the Array in-combination with other plans and projects are not predicted to prevent the population or distribution of grey seal within the site from being maintained. |
| | The distribution of qualifying species within the site are maintained | |

918. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of disturbance due to site-investigation surveys during the construction and operation and maintenance phases of the Array in-combination with other plans and projects.

<u>Southern North Sea SAC</u>

**Harbour porpoise**

*All Tiers*

919. There was no species or SAC specific information available for any of projects identified for in-combination affects for this impact, therefore all Tiers have been addressed here.

920. As detailed in paragraphs 898 *et seq.,* site-investigation surveys for the Tiers 1, 2, and 3 projects are expected to be short term in nature and occur intermittently. In addition, this potential impact is of high reversibility, with animals returning to baseline levels shortly after surveys have ceased. As per the values modelled for the Array alone (section 6.3.3), disturbance ranges are likely to be within the metres to low kilometres depending on the survey technique. For the Array alone, the maximum disturbance range across all geophysical surveys was estimated as 1,340 m for SBP activity and the maximum range across geotechnical activities was 9,101 m for vibrocoring) for all species (see Table 6.37). Therefore, the potential for in-combination effects is reduced, particularly for projects that are tens of kilometres away from the site boundary (such as Bowdun and Campion Offshore Wind Farms in Tier 3). In-combination behavioural disturbance ranges are therefore highly unlikely to overlap with the Southern North Sea SAC, which is a minimum of 129.86 km south-east from the site boundary.

921. For construction and operation and maintenance activities, it is likely that the Tier 1, 2, and 3 projects will also include an MMMP as a designed in measure, similar to that adopted for the Array alone (Table 6.33). As such, and in consideration of the potential designed in measure of an MMMP, population-level effects associated with this potential impact are unlikely for the harbour porpoise feature of this SAC.

*Conclusion*

922. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination disturbance due to site-investigation surveys during the construction and operation and maintenance phases. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.75.

**Table 6.75: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Disturbance due to Site-Investigation Surveys (Including Geophysical Surveys) during the Construction and Operation and Maintenance Phases of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site | Overall, site-investigation surveys in the construction and operation and maintenance phases of the Array in-combination with other plans and projects are unlikely to lead to strong behavioural responses to harbour porpoise. There were no disturbance ranges available for any of the Tier 1, 2, or 3 projects, however the maximum disturbance range modelled for the Array alone was 9,101 m for vibrocoring (Table 6.37). Given the scale and nature of the Tier 1, 2, and 3 projects (other offshore wind farms and a subsea transmission cable), disturbance ranges are likely to be similar to those modelled for the Array alone. Therefore, it is unlikely that disturbance ranges will extend to the SAC (129.86 km away) and therefore animals are unlikely to experience significant disturbance within the site. Site-investigation surveys will therefore not affect areas important for breeding and calving within the SAC, and therefore harbour porpoise will remain a viable component of the site. Overall, including the implementation of designed in mitigation measures, site-investigation surveys associated with the Array in-combination with other plans and projects are not predicted to impact the population from being able to maintain itself as a viable component of the site over the long term. |
| | 2. There is no significant disturbance of the species | As noted in the row above, given that in-combination disturbance ranges are unlikely to extend to the site (129.86 km away), it is anticipated that there will be no significant disturbance to the harbour porpoise feature of the site. |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for potential impact between site-investigation surveys and the habitats and supporting processes of harbour porpoise. With respect to the availability of prey, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.4.5), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support harbour porpoise will not be adversely affected by this potential impact from the Array in-combination with the Tier 1, 2, and 3 projects. |

923. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of disturbance due to site-investigation surveys during the construction and operation and maintenance phases of the Array in-combination with other plans and projects.

Moray Firth SAC

**Bottlenose dolphin**

*All Tiers*

924. There was no species or SAC specific information available for any of projects identified for in-combination affects for this impact, therefore all Tiers have been addressed here.

925. As detailed in paragraphs 898 *et seq.,* site-investigation surveys for the Tiers 1, 2, and 3 projects are expected to be short term in nature and occur intermittently. In addition, this potential impact is of high reversibility, with animals returning to baseline levels shortly after surveys have ceased. As per the values modelled for the Array alone (section 6.3.3), disturbance ranges are likely to be within the metres to low kilometres depending on the survey technique. For the Array alone, the maximum disturbance range across all geophysical surveys was estimated as 1,340 m for SBP activity and the maximum range across geotechnical activities was 9,101 m for vibrocoring) for all species (see Table 6.37). Therefore, the potential for in-combination effects is reduced, particularly for projects that are tens of kilometres away from the site boundary (such as Bowdun and Campion Offshore Wind Farms in Tier 3). In-combination behavioural disturbance ranges are therefore highly unlikely to overlap with the Moray Firth SAC, which is a minimum of 175.86 km north-west from the site boundary.

926. For construction and operation and maintenance activities, it is likely that the Tier 1, 2, and 3 projects will also include an MMMP as a designed in measure, similar to that adopted for the Array alone (Table 6.33). As such, and in consideration of the potential designed in measure of an MMMP, population-level effects associated with this potential impact are unlikely for the bottlenose dolphin feature of this SAC.

*Conclusion*

927. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination disturbance due to site-investigation surveys during the construction and operation and maintenance phases. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.76.

**Table 6.76: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Disturbance due to Site-Investigation Surveys (Including Geophysical Surveys) during the Construction and Operation and Maintenance Phases of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site | Overall, site-investigation surveys in the construction and operation and maintenance phases of the Array in-combination with other plans and projects are unlikely to lead to strong behavioural responses to bottlenose dolphin. There were no disturbance ranges available for any of the Tier 1, 2, or 3 projects, however the maximum disturbance range modelled for the Array alone was 9,101 m for vibrocoring (Table 6.37). Given the scale and nature of the Tier 1, 2, and 3 projects (other offshore wind farms and a subsea transmission cable), disturbance ranges are likely to be similar to those modelled for the Array alone. Therefore, it is unlikely that disturbance ranges will extend to the SAC (175.86 km away) and therefore animals are unlikely to experience significant disturbance within the site. Site-investigation surveys will therefore not affect areas important for breeding and calving within the SAC, and therefore bottlenose dolphin will remain a viable component of the site. Overall, including the implementation of designed in mitigation measures, site-investigation surveys associated with the Array in-combination with other plans and projects are not predicted to impact the population from being able to maintain itself as a viable component of the site. |
| | 2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance | As noted in the row above, given that in-combination disturbance ranges are unlikely to extend to the site (175.86 km away), it is anticipated that there will be no significant disturbance to the bottlenose dolphin feature of the site. |
| | 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained | There is no pathway for potential impact between this potential impact and the habitats and supporting processes of bottlenose dolphin. With respect to the availability of prey, long term effects were not predicted (see volume 2, chapter 9 of the Array EIA Report and the assessment of 'Changes in prey availability' in section 6.4.5), therefore prey species populations are expected to be maintained in the long term. Therefore, the condition of habitats and species required to support bottlenose dolphin will not be adversely affected by this impact. |

928. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of disturbance due to site-investigation surveys during the construction and operation and maintenance phases of the Array in-combination with other plans and projects.

## 6.4.5. CHANGES IN PREY AVAILABILITY

929. The LSE[2] assessment during the HRA Stage One process identified that LSE[2] could not be ruled out for changes in prey availability due to underwater noise from piling and UXO clearance in the construction phase of the Array in-combination with other plans and projects. This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

930. The MDS considered for this in-combination assessment is shown in Table 6.77. The designed in measures are presented in Table 6.43 for the assessment of the Array alone.

**Table 6.77: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Changes in Prey Availability in the Construction Phase of the Array In-Combination with other Plans and Projects**

| Project Phase | Tier | MDS |
|---|---|---|
| Construction | 1 | The MDS is as described above for the Array alone (Table 6.42) has been assessed in-combination with the following plans and projects:<br><br>**Construction Phase**<br>• Proposed offshore export cable corridor(s); and<br>• Berwick Bank Offshore Wind Farm. |
| | 2 | The MDS is as described above for the Array alone (Table 6.42) and has been assessed in-combination with the following plans and projects:<br><br>**Construction Phase**<br>• Morven Offshore Wind Farm;<br>• Cenos Offshore Wind Farm;<br>• Salamander Offshore Wind Farm; and<br>• Tier 1 projects. |
| | 3 | The MDS is as described above for the Array alone (Table 6.42) and has been assessed in-combination with the following plans and projects:<br><br>**Construction Phase**<br>• Morven Offshore Export Cable Corridor(s);<br>• Bellrock Offshore Wind Farm;<br>• Bowdun Offshore Wind Farm;<br>• Campion Offshore Wind Farm;<br>• Cedar Offshore Wind Farm;<br>• Flora Floating Wind Farm;<br>• Aspen Offshore Wind Farm; and<br>• Tier 1 and Tier 2 projects. |

In-combination assessment

931. There is the potential for in-combination impacts due to changes in prey availability in the construction phase of the Array and other plans and projects. For the purposes of this assessment, this potential impact has been assessed using the tiered approach outlined in section 4.6. The plans and projects screened into the in-combination assessment for this potential impact and their respective tiers are outlined in Table 6.77.

932. As concluded in the Array HRA Stage One LSE[2] Screening Report (Array RIAA Part 1, appendix 1A) Annex II grey seal, harbour porpoise, and bottlenose dolphin are likely to be present within the Array marine mammal study area and may forage within the area. Effects on prey fish populations across all phases of the Array alone, and in-combination with other plans and projects, are likely to be temporary, of a short

duration, localised and not significant (as per the conclusions presented for the assessment on Annex II diadromous fish; section 5.3). The widest ranging effect was concluded to be of increased underwater noise during the construction phase (mainly due to piling) and is unlikely to be significant in other phases (Array RIAA Part 1, appendix 1A). However, as impacts to prey species have been assessed as part of the underwater noise modelling assessment that has been undertaken for the EIA, this potential impact was included for the construction phase in the in-combination assessment as a precaution for the Annex II marine mammal features of their respective SACs.

Tier 1

933. There were two Tier 1 projects identified with potential for in-combination effects associated with this impact:

- Proposed offshore export cable corridor(s); and
- Berwick Bank Offshore Wind Farm (Table 6.77).

934. Currently, there is no EIA Report available for the Proposed offshore export cable corridor(s), though construction is likely to be of medium duration, with noise being intermittent. Although there is no information on construction activities associated with the Proposed offshore export cable corridor(s), it is not expected that piling will be included in the project description (as this is a cable project). As such, noise impacts which have the potential to affect prey species are expected to be limited to UXO clearance operations during site preparation. While there is no site-specific information on these impacts, it is expected they would be similar to those assessed for the project alone (i.e. minor significance, see volume 2, chapter 9 of the EIA Report).

935. The Berwick Bank Offshore Wind Farm underwater noise assessment considered effects (including mortality, injury and behavioural effects) on a similar range of fish and shellfish receptors as the Array alone (volume 2, chapter 9 of the Array EIA Report). The Berwick Bank assessment predicted that injurious effects on fish would be limited in extent and behavioural effects would occur across a wider area of up to tens of kilometres (SSE Renewables, 2022b). The effects would be temporary, reversible and would not result in significant effects on fish and shellfish receptors (SSE Renewables, 2022b). In the marine mammal assessment for the Berwick Bank EIA, changes in prey availability was therefore concluded to be of minor adverse significance for all species (SSE Renewables, 2022c).

936. The construction of the Array, and of Berwick Bank Offshore Wind Farm, will coincide for only two years (2031 and 2032). Furthermore, due to the large distance between the projects (56.84 km), there is limited potential for noise contours to interact. Given that UXO clearance is typically undertaken at the beginning of the construction phase, there is likely to be no temporal overlap in UXO clearance associated with the Array and Berwick Bank Offshore Wind Farm (where the construction phase is currently anticipated as 2025 to 2032 (Table 6.57).

937. It is likely that the Tier 1 projects will involve similar designed in mitigation as the Array (Table 6.43), such as piling soft starts and low order UXO disposal. These will reduce the risk of injury to prey fish species in the immediate vicinity of piling or UXO operations, either by allowing some species/individuals to flee the area before noise levels reach a level at which injury may occur, and/or by limiting the total amount of noise energy entering the environment.

938. With respect to indirect effects on marine mammals, no additional in-combination effects due to changes in prey availability are predicted (with no significant cumulative effects predicted for fish and shellfish species in the EIA Report). As discussed in the alone assessment (section 6.3.4), all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

Tier 2

939. In addition to the Tier 1 projects, there were three Tier 2 projects identified with potential for in-combination effects associated with this impact:

- Morven Offshore Wind Farm;
- Cenos Offshore Wind Farm; and
- Salamander Offshore Wind Farm (Table 6.77).

940. Currently, only Scoping Reports are available for the Tier 2 projects, though piling activities during their construction phases are expected to be similar in nature as that of the Array. Although information on hammer energies and piling durations are not available for the Tier 2 projects, the potential impact is likely to be of medium duration, with noise being intermittent during the construction phase. As detailed in Table 6.57, the construction phase of the Morven Offshore Wind Farm is anticipated to largely overlap temporally with that of the Array, however dates are currently unavailable for the other two Tier 2 projects.

941. It is likely that the Tier 2 projects will involve similar designed in mitigation as the Array (Table 6.43), such as piling soft starts and low order UXO disposal. These will reduce the risk of injury to prey fish species in the immediate vicinity of piling or UXO operations, either by allowing some species/individuals to flee the area before noise levels reach a level at which injury may occur, and/or by limiting the total amount of noise energy entering the environment.

942. Within the fish and shellfish ecology CEA (volume 2, chapter 9 of the Array EIA Report), cumulative effects from underwater noise were assessed as being of minor adverse significance for all fish and shellfish receptors in the Tier 2 assessment. With respect to indirect effects on marine mammals, no additional in-combination effects due to changes in prey availability are predicted (as no significant cumulative effects predicted for fish and shellfish in the EIA Report). As discussed in the alone assessment (section 6.3.4), all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging and highly mobile in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

Tier 3

943. In addition to the Tier 1 and Tier 2 projects, there were seven Tier 3 projects identified with potential for in-combination effects associated with this impact:

- Morven Offshore Export Cable Corridor(s);
- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm;
- Cedar Offshore Wind Farm;
- Flora Floating Wind Farm;
- Aspen Offshore Wind Farm (Table 6.77).

944. Tier 3 projects are in a pre-application phase and no EIA Scoping Report, EIA Report, or HRA documentation are available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

945. As these are Tier 3 projects, there are no Scoping Reports in the public domain. Therefore, there is no information available on the potential impact that these Tier 3 projects will have on prey fish species, although piling activities during the construction phase are expected to be similar in nature as that of the Array. Whilst information on hammer energies and piling durations are not available for the Tier 3 projects, the potential impact is likely to be of medium duration, with noise being intermittent during the construction phase.

946. The maximum duration of the offshore construction phase for the Array is up to eight years (2031 to 2038). There is currently no information available on the various Tier 3 projects; therefore, a precautionary

assumption has been made that these may have overlapping piling phases with the Array (Table 6.57). Therefore, there may be minimal temporal overlap between the construction activities of the Array and that of the Tier 3 projects, and thus, reduced potential for in-combination effects associated with this impact.

947. It is likely that the Tier 3 projects will involve similar designed in mitigation as the Array (Table 6.43), such as piling soft starts and low order UXO disposal. These will reduce the risk of injury to prey fish species in the immediate vicinity of piling or UXO operations, either by allowing some species/individuals to flee the area before noise levels reach a level at which injury may occur, and/or by limiting the total amount of noise energy entering the environment.

948. Within the fish and shellfish ecology CEA (volume 2, chapter 9 of the Array EIA Report), cumulative effects from underwater noise were assessed as being of minor adverse significance for all fish and shellfish receptors in the Tier 3 assessment. With respect to indirect effects on marine mammals, no additional in-combination effects due to changes in prey availability are predicted (as no significant cumulative effects predicted for fish and shellfish in the EIA Report). As discussed in the alone assessment (section 6.3.4), all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging and mobile in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

### Construction phase

<u>Berwickshire and North Northumberland Coast SAC</u>

**Grey seal**

*Tier 1*

949. The results of the underwater noise modelling for the Array alone suggest that prey species may be impacted due to underwater noise up to tens of kilometres from the site boundary (volume 2, chapter 9 of the EIA Report). Similarly, ranges of injury and disturbance to prey species from piling and UXO clearance at Berwick Bank were predicted to be limited in extent, with behavioural effects potentially occurring over a wider area of up to tens of kilometres (SSE Renewables, 2022b). Although there is no information on construction activities associated with the Proposed offshore export cable corridor(s), it is expected they would be similar to those assessed for the project alone (i.e. minor significance, see volume 2, chapter 9 of the EIA Report). Therefore, underwater noise only has the potential to impact prey species over a relatively small area in terms of the regional marine mammal study area as a whole.

950. As detailed in the assessment on the Array alone (section 6.3.4), the availability of wider suitable foraging habitat across the regional marine mammal study area suggests that grey seals would not be impacted by any localised and intermittent changes in prey availability associated with the Array in-combination with the Tier 1 projects. It is expected that the grey seal population would be able to tolerate the effect without any potential impact on reproduction and survival rates.

951. Overall, this potential impact is not predicted to result in adverse effects (i.e. disruption to foraging) for the grey seal feature of this SAC as a result of the Array in-combination with the Tier 1 projects.

*Tier 2*

952. The Tier 2 assessment, presented in paragraphs 939 *et seq.,* concluded that in-combination effects are unlikely to occur. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 2 projects. Based on this, it is concluded that in-combination changes in prey availability associated with at the Array and the Tier 2 projects will not have an adverse effect on the integrity of the grey seal feature of this SAC.

*Tier 3*

953. The Tier 3 assessment, presented in paragraphs 943 *et seq.,* highlighted that it was not possible to undertake any meaningful in-combination assessment for the nine Tier 3 projects identified for this impact. This was due to the lack of publicly available information surrounding piling and UXO clearance parameters. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 3 projects. Based on this, it is concluded that in-combination changes in prey availability associated with at the Array and the Tier 3 projects will not have an adverse effect on the integrity of the grey seal feature of this SAC.

*Conclusion*

954. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination changes in prey availability during the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in in section 6.2.1) are discussed in turn below in Table 6.78.

**Table 6.78: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Changes in Prey Availability during the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for potential impact between changes in prey availability and the extent, distribution, structure and function of habitats and supporting processes of grey seal. Overall, this impact, associated with the Array in-combination with other plans and projects, will not prevent these conservation objectives from being maintained. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | Impacts to prey species are predicted to be insignificant, and grey seal expected to adapt and recover quickly. Further, due to the availability of wide foraging habitat in the regional marine mammal study area, and the wide foraging nature of grey seals (up to and over 100 km (SCOS, 2023), this species is likely to be tolerant to localised changes in prey availability<br><br>As such there is a negligible risk of disruption of foraging activities of grey seal. Therefore, changes in prey availability associated with underwater noise in the construction phase of the Array in-combination with other plans and projects will not affect the survivability and reproductive potential of grey seal within the SAC. Similarly, changes in prey availability will not significantly disturb the species. As such, and with additional consideration of the designed in measures, changes in prey availability are not predicted to prevent the population or distribution of grey seal within the site from being maintained. |
| | The distribution of qualifying species within the site are maintained | |

955. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of changes in prey availability in the construction phase of the Array in-combination with other plans and projects.

Southern North Sea SAC

**Harbour porpoise**

*Tier 1*

956. The results of the underwater noise modelling for the Array alone suggest that prey species may be impacted due to underwater noise up to tens of kilometres from the site boundary (volume 2, chapter 9 of the EIA Report). Similarly, ranges of injury and disturbance to prey species from piling and UXO clearance at Berwick Bank were predicted to be limited in extent, with behavioural effects potentially occurring over a wider area of up to tens of kilometres (SSE Renewables, 2022b). Although there is no information on construction activities associated with the Proposed offshore export cable corridor(s), it is expected they would be similar to those assessed for the project alone (i.e. minor significance, see volume 2, chapter 9 of the EIA Report). Therefore, underwater noise only has the potential to impact prey species over a relatively small area in terms of the regional marine mammal study area as a whole.

957. As detailed in the assessment on the Array alone (section 6.3.4), the availability of wider suitable foraging habitat across the regional marine mammal study area and the generalist feeding habits of harbour porpoise suggests that individuals would not be impacted by any localised and intermittent changes in prey availability associated with the Array in-combination with the Tier 1 projects. It is expected that the harbour porpoise population would be able to tolerate the effect without any potential impact on reproduction and survival rates.

958. Overall, this potential impact is not predicted to result in adverse effects (i.e. disruption to foraging) for the harbour porpoise feature of this SAC as a result of the Array in-combination with the Tier 1 projects.

*Tier 2*

959. The Tier 2 assessment, presented in paragraphs 939 *et seq.,* concluded that in-combination effects are unlikely to occur. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 2 projects. Based on this, it is concluded that in-combination changes in prey availability associated with at the Array and the Tier 2 projects will not have an adverse effect on the integrity of the harbour porpoise feature of this SAC.

*Tier 3*

960. The Tier 3 assessment, presented in paragraphs 943 *et seq.,* highlighted that it was not possible to undertake any meaningful in-combination assessment for the nine Tier 3 projects identified for this impact. This was due to the lack of publicly available information surrounding piling and UXO clearance parameters. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 3 projects. Based on this, it is concluded that in-combination changes in prey availability associated with at the Array and the Tier 3 projects will not have an adverse effect on the integrity of the harbour porpoise feature of this SAC.

*Conclusion*

961. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination changes in prey availability during the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.79.

**Table 6.79: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Changes in Prey Availability during the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site<br>2. There is no significant disturbance of the species | In-combination impacts to prey species are predicted to be insignificant, and harbour porpoise are expected to adapt and recover quickly. This is due to their generalist feeding strategy, highly mobile nature, and wide distributional range. As such there is a negligible risk of disruption of foraging activities of harbour porpoise. Therefore, changes in prey availability associated with underwater noise in the construction phase of the Array in-combination with other plans and projects will not affect the survivability and reproductive potential of harbour porpoise within the SAC and they will remain a viable component of the site. Similarly, changes in prey availability will not significantly disturb the species. As such, and with additional consideration of the designed in measures, changes in prey availability are not predicted to impact the population from being able to maintain itself as a viable component of the site or cause significant disturbance to harbour porpoise. |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for potential impact between changes in prey availability and the habitats and supporting processes of harbour porpoise. There were no significant adverse impacts predicted for fish and shellfish species in the Berwick Bank EIA (SSE Renewables, 2022b) or the Array alone (see volume 2, chapter 9 of the Array EIA Report). There was insufficient publicly available information on the impacts of the other Tier 1, 2, and 3 projects on prey fish species. However, due to the availability of wide foraging habitat in the regional marine mammal study area, this species is likely to be tolerant to localised changes in prey availability. Therefore, this impact, associated with the Array in-combination with other plans and projects, will not prevent this conservation objective from being maintained. |

962. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of changes in prey availability in the construction phase of the Array in-combination with other plans and projects.

Moray Firth SAC

**Bottlenose dolphin**

*Tier 1*

963. The results of the underwater noise modelling for the Array alone suggest that prey species may be impacted due to underwater noise up to tens of kilometres from the site boundary (volume 2, chapter 9 of the EIA Report). Similarly, ranges of injury and disturbance to prey species from piling and UXO clearance at Berwick Bank were predicted to be limited in extent, with behavioural effects potentially occurring over a wider area of up to tens of kilometres (SSE Renewables, 2022b). Although there is limited information on construction activities associated with the Proposed offshore export cable corridor(s), it is expected they would be similar to those assessed for the project alone (i.e. minor significance, see volume 2, chapter 9 of the EIA Report). Therefore, underwater noise only has the potential to impact prey species over a relatively small area in terms of the regional marine mammal study area as a whole.

964. As detailed in the assessment on the Array alone (section 6.3.4), the availability of wider suitable foraging habitat across the regional marine mammal study area and the generalist feeding habits of bottlenose dolphin suggests that individuals would not be impacted by any localised and intermittent changes in prey availability associated with the Array in-combination with the Tier 1 projects. It is expected that the bottlenose dolphin population would be able to tolerate the effect without any potential impact on reproduction and survival rates.

965. Overall, this potential impact is not predicted to result in adverse effects (i.e. disruption to foraging) for the bottlenose dolphin feature of this SAC as a result of the Array in-combination with the Tier 1 projects.

*Tier 2*

966. The Tier 2 assessment, presented in paragraphs 939 *et seq.,* concluded that in-combination effects are unlikely to occur. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect for this potential impact associated with the Tier 2 projects. Based on this, it is concluded that in-combination changes in prey availability associated with at the Array and the Tier 2 projects will not have an adverse effect on the integrity of the bottlenose dolphin feature of this SAC.

*Tier 3*

967. The Tier 3 assessment, presented in paragraphs 943 *et seq.,* highlighted that it was not possible to undertake any meaningful in-combination assessment for the nine Tier 3 projects identified for this impact. This was due to the lack of publicly available information surrounding piling and UXO clearance parameters. The CEA presented in the Array EIA Report (volume 2, chapter 10 of the Array EIA Report) concluded a minor significance of effect associated with the Tier 3 projects. Based on this, it is concluded that in-combination changes in prey availability associated with at the Array and the Tier 3 projects will not have an adverse effect on the integrity of the bottelenose dolphin feature of this SAC.

*Conclusion*

968. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination changes in prey availability during the construction phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.80.

**Table 6.80: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Changes in Prey Availability during the Construction Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site | In-combination impacts to prey species are predicted to be insignificant, and bottlenose dolphin are expected to adapt and recover quickly. As such there is a negligible risk of disruption of foraging activities of bottlenose dolphin. Therefore, changes in prey availability associated with underwater noise in the construction phase of the Array in-combination with other plans and projects will not affect the survivability and reproductive potential of this species within the SAC and they will remain a viable component of the site. Similarly, changes in prey availability will not significantly disturb bottlenose dolphin. This is due to their generalist feeding strategy and wide ranging nature. As such, and with additional consideration of the designed in measures, changes in prey availability are not predicted to impact the population from being able to maintain itself as a viable component of the site, impact the distribution, orcause significant disturbance to bottlenose dolphin. |
| | 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 | There is no pathway for potential impact between changes in prey availability and the habitats and supporting processes of bottlenose dolphin. There were no significant adverse impacts predicted for fish and shellfish species in the Berwick Bank EIA (SSE Renewables, 2022b) or the Array alone (see volume 2, chapter 9 of the Array EIA Report). There was insufficient publicly available information on the impacts of the other Tier 1, 2, and 3 projects on prey fish species. However, due to the availability of wide foraging habitat in the regional marine mammal study area, this species is likely to be tolerant to localised changes in prey availability. Therefore, this impact, associated with the Array in-combination with other plans and projects, will not prevent this conservation objective from being maintained. |

969. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of changes in prey availability in the construction phase of the Array in-combination with other plans and projects.

### 6.4.6. ENTANGLEMENT

970. The LSE[2] assessment during the HRA Stage One process identified that LSE[2] could not be ruled out for entanglement in the operation and maintenance phase of the Array in-combination with other plans and projects. This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

971. The MDS considered for this in-combination assessment is shown in Table 6.81. The secondary mitigation measures are presented in Table 6.48 for the assessment of the Array alone. Fixed bottom projects were screened out of the in-combination assessment on the basis that there are no mooring lines or dynamic

cabling in the water column that could present a risk of primary or secondary entanglement to marine mammals.

**Table 6.81: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Entanglement during the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Project Phase | Tier | MDS |
|---|---|---|
| Operation and maintenance phase | 1 | There were no Tier 1 projects identified within the 50 km search buffer for this impact. |
| | 2 | There were no Tier 2 projects identified within the 50 km search buffer for this impact. |
| | 3 | The MDS is as described above for the Array alone (Table 6.47) assessed in-combination with operation and maintenance phases of the following projects within the 50 km search buffer:<br>• Bellrock Offshore Wind Farm; and<br>• Campion Offshore Wind Farm. |

In-combination assessment

972. There is the potential for in-combination impacts due to changes in prey availability in the construction phase of the Array and other plans and projects. For the purposes of this assessment, this potential impact has been assessed using the tiered approach outlined in section 4.6. The plans and projects screened into the in-combination assessment for this potential impact and their respective tiers are outlined in Table 6.81.

Tier 1 and 2

973. There were no Tier 1 or Tier 2 projects identified with the potential for entanglement risk (i.e. floating offshore wind projects) within the 50 km search buffer.

Tier 3

974. There were two Tier 3 floating offshore wind projects identified within the 50 km buffer region with potential for in-combination effects associated with this impact:

- Bellrock Offshore Wind Farm; and
- Campion Offshore Wind Farm (Table 6.81).

975. These Tier 3 projects are in a pre-application phase and no EIA Scoping Report, EIA Report, or HRA Documentation are available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

976. As described in Table 6.48 for the Array alone, mooring lines and dynamic inter-array cables are likley to undergo routine inspections during the operation and maintenance phase, employing a risk-based adaptive management approach. All Tier 3 projects are located in excess of 50 km from the site boundary except for Bellrock, Bowdun, and Campion Offshore Wind Farms (Figure 6.13). Of these projects only Bellrock and Campion Offshore Wind Farms are floating projects and may contribute to the cumulative impacts of entanglement. Only floating offshore wind farms have been considered in this in-combination assessment, as there is no risk of entanglement from fixed bottom wind farms (due to their lack of mooring lines).

977. The risks of entanglement from floating offshore wind farms are not fully understood (see paragraphs 700 *et seq*.) but the commitment of the Array to monitor and manage the risks (Table 6.48) will reduce any potential contribution to in-combination effects with other projects. There are no published standard industry measures at the time of writing but should other wind projects adopt a similar 'monitor and manage' approach, it is likely that the potential for in-combination effects would be further reduced. Considering the implementation of these designed in measures during the operations and maintenance phase of the Array, the potential for in-combination effects resulting from entanglement is considered very unlikely.

978. The risk of entanglement due to presence of mooring lines and dynamic inter-array cables in the water column is predicted to be of very local spatial extent in the context of the geographic frame of reference. It is predicted that the potential impact will affect marine mammals directly in the case of both (rare) primary entanglement and secondary entanglement, however the risk of secondary entanglement is sufficiently reduced with the application of the designed in mitigation measures (routine surveys and removal of marine debris as required following inspection) and any population-level effects are highly unlikely (Table 6.48). Based on this, it is concluded that in-combination entanglement associated with the Array and the Tier 3 projects will not have an adverse effect on the integrity of the marine mammal features of the SACs assessed in this Part of the RIAA.

Operation and maintenance phase

Berwickshire and North Northumberland Coast SAC

**Grey seal**

979. As detailed in paragraphs 974 *et seq.,* there were only two Tier 3 projects identified for in-combination assessment associated with this impact: Bellrock and Campion Offshore Wind Farms. Due to the lack of publicly available information on these projects, only a qualitative assessment was provided. Based on the assessment in paragraphs 974 *et seq*., it has been concluded that population-level effects on the grey seal feature of this SAC are highly unlikely.

*Conclusion*

980. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination entanglement during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in in section 6.2.1) are discussed in turn below in Table 6.82.

**Table 6.82: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Entanglement during the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for potential impact between in-combination entanglement and the extent, distribution, structure and function of habitats and the supporting processes of grey seal. Therefore, this potential impact will not prevent these conservation objectives from being maintained as a result of the Array in-combination with Tier 3 projects. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | As concluded from the background literature reviewed in paragraphs 700 *et seq.*, population-level effects on grey seal due to entanglement are not likely to occur. The, already low, but increased risk of entanglement associated with the Array in-combination with the Tier 3 projects will also not affect areas important for breeding and pupping within the SAC (which is 113.95 km away from the site boundary), and therefore grey seal will remain a viable component of the site. Further, as individuals typicaly remain within 20 km of the coast during the breeding season (*pers. comm.* NatureScot), the potential for individals to experience entanglement is further reduced during this key iife cycle stage (given the 113.95 km distance to the site boundary). Overall, including the implementation of designed in mitigation measures of regular inspections of mooring lines and dynamic cables, entanglement will not prevent the population or distribution of grey seal within the site from being maintained as a result of the Array in-combination with Tier 3 projects. |
| | The distribution of qualifying species within the site are maintained | |

981. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of entanglement during the operation and maintenance phase of the Array in-combination with other plans and projects.

Southern North Sea SAC

**Harbour porpoise**

982. As detailed in paragraphs 974 *et seq.,* there were only two Tier 3 projects identified for in-combination assessment associated with this impact: Bellrock and Campion Offshore Wind Farms. Due to the lack of publicly available information on these projects, only a qualitative assessment was provided here. Based on the assessment in paragraphs 974 *et seq*., it has been concluded that population-level effects on the harbour porpoise feature of this SAC are highly unlikely.

*Conclusion*

983. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination entanglement during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.83.

**Table 6.83: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Entanglement during the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site | As concluded from the background literature reviewed in paragraphs 700 *et seq.*, population-level effects on harbour porpoise due to entanglement are not likely to occur. The, already low, but increased risk of entanglement associated with the Array in-combination with the Tier 3 projects will also not affect areas important for breeding and calving within the SAC (which is 129.86 km away from the site boundary), and therefore harbour porpoise will remain a viable component of the site. Overall, including the implementation of designed in mitigation measures of regular inspections of mooring lines and dynamic cables, entanglement is not predicted to impact the population from being able to maintain itself as a viable component of the site or cause significant disturbance to the species. |
| | 2. There is no significant disturbance of the species | |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for potential impact between in-combination entanglement and the habitats, supporting processes, and prey species of harbour porpoise. Therefore, this potential impact will not prevent this conservation objective from being maintained as a result of the Array in-combination with Tier 3 projects. |

984. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of entanglement during the operation and maintenance phase of the Array in-combination with other plans and projects.

Moray Firth SAC

**Bottlenose dolphin**

985. As detailed in paragraphs 974 *et seq.,* there were only two Tier 3 projects identified for in-combination assessment associated with this impact: Bellrock and Campion Offshore Wind Farms. Due to the lack of publicly available information on these projects, only a qualitative assessment was provided. Based on the assessment in paragraphs 974 *et seq*., it has been concluded that population-level effects on the bottlenose dolphin feature of this SAC are highly unlikely.

*Conclusion*

986. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination entanglement during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.84.

**Table 6.84: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Entanglement during the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site | As concluded from the background literature reviewed in paragraphs 700 *et seq.*, population-level effects on bottlenose dolphin due to entanglement are not likely to occur. The already low, but increased risk of entanglement associated with the Array in-combination with the Tier 3 projects will also not affect areas important for breeding and calving within the SAC (which is 175.86 km away from the site boundary), and therefore bottlenose dolphin will remain a viable component of the site. Overall, including the implementation of designed in mitigation measures of regular inspections of mooring lines and dynamic cables, entanglement is not predicted to impact the population from being able to maintain itself as a viable component of the site, impact the distribution of bottlenose dolphin, nor cause significant disturbance to the species. |
| | 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 | There is no pathway for potential impact between in-combination entanglement and the habitats, supporting processes, and prey species of bottlenose dolphin. Therefore, this potential impact will not prevent this conservation objective from being maintained as a result of the Array in-combination with Tier 3 projects. |

987. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of entanglement during the operation and maintenance phase of the Array in-combination with other plans and projects.

## 6.4.7. INJURY AND DISTURBANCE FROM UNDERWATER NOISE GENERATED DURING THE OPERATION OF FLOATING WIND TURBINES AND ANCHOR MOORING LINES

988. The LSE[2] assessment during the HRA Stage One process identified that LSE[2] could not be ruled out for operational noise in the operation and maintenance phase of the Array in-combination with other plans and projects. This relates to the following sites and relevant Annex II marine mammal features:

- Berwickshire and North Northumberland Coast SAC;
  - grey seal.
- Southern North Sea SAC; and
  - harbour porpoise.
- Moray Firth SAC;
  - bottlenose dolphin.

989. The MDS considered for this in-combination assessment is shown in Table 6.85.

**Table 6.85: MDS Considered for the Assessment of Potential Impacts to Annex II Marine Mammals due to Operational Noise during the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Project Phase | Tier | MDS |
|---|---|---|
| Operation and maintenance phase | 1 | There were no Tier 1 projects identified within the 50 km search buffer for this impact. |
| | 2 | The MDS is as described above for the Array alone (Table 6.52) assessed in-combination with operation and maintenance phase of the following project within the 50 km search buffer:<br>• Morven Offshore Wind Farm. |
| | 3 | The MDS is as described above for the Array alone (Table 6.52) assessed in-combination with operation and maintenance phases of the following projects within the 50 km search buffer:<br>• Bellrock Offshore Wind Farm;<br>• Bowdun Offshore Wind Farm;<br>• Campion Offshore Wind Farm; and<br>• the Tier 2 project. |

### In-combination assessment

990. There is the potential for in-combination impacts due to changes in operational noise during the operation and maintenance phase of the Array and other plans and projects. For the purposes of this assessment, this potential impact has been assessed using the tiered approach outlined in section 4.6. The plans and projects screened into the in-combination assessment for this potential impact and their respective tiers are outlined in Table 6.85.

Tier 1

991. There were no Tier 1 projects with turbines (and therefore the potential for any in-combination operational noise) identified within the 50 km search buffer, and therefore there is no in-combination effect predicted from additional Tier 1 projects.

Tier 2

992. There was one Tier 2 project identified within 50 km buffer with potential for in-combination effects associated with this impact:

- Morven Offshore Wind Farm (Table 6.85).

993. As for the Array alone (section 6.3.6), impacts related to operational noise from turbines and anchor mooring lines are expected to be localised to within the close vicinity of the respective projects and as such, the assessment only focussed on projects within a representative 50 km buffer of the Array as a proportionate approach.

994. Whilst there is the potential for the operations and maintenance phase of Morven Offshore Wind Farm to overlap with the operations and maintenance phase of the Array, this potential impact was scoped out in the Morven Offshore Scoping Report (Morven Offshore Wind Limited, 2023). This project is therefore not considered further in the Tier 2 assessment.

Tier 3

995. There were three Tier 3 projects identified with potential for in-combination effects associated with this impact:

- Bellrock Offshore Wind Farm;

- Bowdun Offshore Wind Farm; and
- Campion Offshore Wind Farm (Table 6.85).

996. The Tier 3 projects are in a pre-application phase and no EIA Scoping Report, EIA Reports, or HRA Documentation are available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

997. Operational noise from anchor mooring lines is likely to be considerably lower compared to underwater noise associated with piling and UXO clearance activities during the construction phase. Most Tier 3 projects are located in excess of 50 km from the Array. The exceptions are Bellrock, Bowdun, and Campion Offshore Wind Farms, and of these only Bellrock and Campion are floating projects. All three projects may contribute to cumulative effects with respect to operational noise (from either floating or fixed foundations) but are located between 8.67 km (Bellrock) to 44.15 km (Campion) from the Array (with the effects of operational noise likely to be highly localised) and therefore unlikely to lead to any significant in-combination effects.

998. The Array alone assessment (see paragraph 740 *et seq.*) drew on a study completed at the Hywind Pilot Park in Scotland by Burns *et al.* (2022). In this study, the authors concluded that the maximum distance at which the TTS could occur across all hearing groups was estimated for harbour porpoise at 50 m from a turbine assuming that the animal would remain stationary for the 24 hour period (Burns *et al.*, 2022). The study concluded that even at a wind speed of 25 knots, the noise footprint is negligible and in the relatively noisy soundscape of the North Sea, it does not present any realistic threat of auditory injury to marine species. As discussed in paragraph 740 *et seq.,* Risch *et al.* (2023a) found noise emissions from floating offshore wind turbines were similar to the operational noise of fixed offshore wind turbines, with biggest difference between fixed and floating offshore wind turbines in relation to underwater noise generation is mooring-related noise, rather the operational wind turbine noise.

999. Considering Bellrock, Bowdun and Campion Offshore Wind Farms are located over 8 km from the site boundary (in differing directions), and on the basis of the estimated TTS ranges associated with operational noise, the potential for in-combination impact is unlikely.

1000. Based on the information presented in paragraphs 995 *et seq.*, it has been concluded that population-level effects on the marine mammal features of their respective SACs are highly unlikely.

### Operation and maintenance phase

<u>Berwickshire and North Northumberland Coast SAC</u>

**Grey seal**

1001. As detailed in paragraphs 995 *et seq.,* there were only three Tier 3 projects included in the in-combination assessment for this impact: Bellrock and Campion Offshore Wind Farms. Due to the lack of publicly available information on these projects, only a qualitative assessment was provided. Based on the information presented in paragraphs 995 *et seq.*, it has been concluded that population-level effects on the grey seal feature of this SAC are highly unlikely.

*Conclusion*

1002. Adverse effects on the qualifying Annex II marine mammal features of the Berwickshire and North Northumberland Coast SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination operational noise during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in in section 6.2.1) are discussed in turn below in Table 6.86.

**Table 6.86: Conclusions Against the Conservation Objectives of the Berwickshire and North Northumberland Coast SAC from Operational Noise during the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (Natural England, 2020) | Conclusion |
|---|---|---|
| Grey seal | The extent and distribution of qualifying natural habitat and habitats of the qualifying species are maintained | There is no pathway for potential impact between in-combination operational noise and the extent, distribution, structure and function of habitats and the supporting processes of grey seal. Therefore, this in-combination potential impact will not prevent these conservation objectives from being maintained. |
| | The structure and function of the habitats of the qualifying species are maintained | |
| | The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely are maintained | |
| | The populations of each of the qualifying species are maintained | As detailed from the Tier 3 assessment, population-level effects on grey seal due to operational noise are not likely to occur. Given that potential injury and disturbance ranges are likely to be low and highly localised, operational noise will also not affect areas important for breeding and pupping within the SAC, and therefore grey seal will remain a viable component of the site. Overall, this in-combination impact will not prevent the population or distribution of grey seal within the site from being maintained. |
| | The distribution of qualifying species within the site are maintained | |

1003. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Berwickshire and North Northumberland Coast SAC as a result of operational noise in the operation and maintenance phase of the Array in-combination with other plans and projects.

<u>Southern North Sea SAC</u>

**Harbour porpoise**

1004. As detailed in paragraphs 995 *et seq.,* there were only three Tier 3 projects included in the in-combination assessment for this impact: Bellrock, Bowdun, and and Campion Offshore Wind Farms. Due to the lack of publicly available information on these projects, only a qualitative assessment was provided. Based on the information presented in paragraphs 995 *et seq.*, it has been concluded that population-level effects on the harbour porpoise feature of this SAC are highly unlikely.

*Conclusion*

1005. Adverse effects on the qualifying Annex II marine mammal features of the Southern North Sea SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination operational noise during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.2) are discussed in turn below in Table 6.87.

**Table 6.87: Conclusions Against the Conservation Objectives of the Southern North Sea SAC from Operational Noise during the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (JNCC and Natural England, 2019) | Conclusion |
|---|---|---|
| Harbour porpoise | 1. Harbour porpoise is a viable component of the site<br>2. There is no significant disturbance of the species | As detailed from the Tier 3 assessment, population-level effects on harbour porpoise due to operational noise are not likely to occur. Given that potential injury and disturbance ranges are likely to be low and highly localised, operational noise will also not affect areas important for breeding and calving within the SAC, and therefore harbour porpoise will remain a viable component of the site. Overall, this in-combination impact is not predicted to impact the population from being able to maintain itself as a viable component of the site or cause significant disturbance to the species. |
| | 3. The condition of supporting habitats and processes, and the availability of prey is maintained | There is no pathway for potential impact between in-combination operational noise and the habitats, supporting processes, and prey species of harbour porpoise. Therefore, this in-combination impact will not prevent this conservation objective from being maintained. |

1006. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Southern North Sea SAC as a result of operational noise in the operation and maintenance phase of the Array in-combination with other plans and projects.

Moray Firth SAC

**Bottlenose dolphin**

1007. As detailed in paragraphs 995 *et seq.,* there were only three Tier 3 projects included in the in-combination assessment for this impact: Bellrock and Campion Offshore Wind Farms. Due to the lack of publicly available information on these projects, only a qualitative assessment was provided. Based on the information presented in paragraphs 995 *et seq.*, it has been concluded that population-level effects on the bottlenose dolphin feature of this SAC are highly unlikely.

*Conclusion*

1008. Adverse effects on the qualifying Annex II marine mammal features of the Moray Firth SAC which undermine the conservation objectives of the SAC will not occur as a result of in-combination operational noise during the operation and maintenance phase. Potential effects from this activity on the relevant conservation objectives (as presented in section 6.2.3) are discussed in turn below in Table 6.88.

**Table 6.88: Conclusions Against the Conservation Objectives of the Moray Firth SAC from Operational Noise during the Operation and Maintenance Phase of the Array In-Combination with other Plans and Projects**

| Feature | Conservation Objectives (NatureScot, 2021) | Conclusion |
|---|---|---|
| Bottlenose dolphin | 2a. The population of bottlenose dolphin is a viable component of the site<br>2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance | As detailed from the Tier 3 assessment, population-level effects on bottlenose dolphin due to operational noise are not likely to occur. Given that potential injury and disturbance ranges are likely to be low and highly localised, operational noise will also not affect areas important for breeding and calving within the SAC, and therefore bottlenose dolphin will remain a viable component of the site. Overall, this in-combination impact is not predicted to impact the population from being able to maintain itself as a viable component of the site, impact the distribution of this species, nor cause significant disturbance to the species. |
| | 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained | There is no pathway for potential impact between this in-combination operational noise and the habitats, supporting processes, and prey species of bottlenose dolphin. Therefore, this in-combination impact will not prevent this conservation objective from being maintained. |

1009. It can be concluded, beyond reasonable scientific doubt, that there is no risk of an adverse effect on the integrity of the Moray Firth SAC as a result of operational noise in the operation and maintenance phase of the Array in-combination with other plans and projects.

# 7. SUMMARY

1010. A summary of the assessments presented in this RIAA, considering the relevant SACs, is provided in the sections below. Table 7.1 presents the conclusions of Adverse Effects on Integrity in relation to the Array alone and in-combination with other plans and projects.

**Table 7.1: Summary of Conclusions**

| Site ID | Site Name | Relevant Qualifying Features | Project Phase | Potential Impact | Conclusion for the Assessment on the Array Alone | Conclusion for the Assessment on the Array In-Combination with other Plans and Projects |
|---|---|---|---|---|---|---|
| **Annex II Diadromous Fish** | | | | | | |
| UK0030251 | River Dee SAC | Atlantic salmon and freshwater pearl mussel | Construction | Underwater noise generated during piling and UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Effects due to EMFs from subsea electrical cabling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| UK0030262 | River South Esk SAC | Atlantic salmon and freshwater pearl mussel | Construction | Underwater noise generated during piling and UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Effects due to EMFs from subsea electrical cabling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| UK0030292 | Tweed Estuary SAC | Sea lamprey | Construction | Underwater noise generated during piling and UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Effects due to EMFs from subsea electrical cabling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| UK0012691 | River Tweed SAC | Atlantic salmon and sea lamprey | Construction | Underwater noise generated during piling and UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Effects due to EMFs from subsea electrical cabling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| UK0030312 | River Tay SAC | Atlantic salmon and sea lamprey | Construction | Underwater noise generated during piling and UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Effects due to EMFs from subsea electrical cabling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| UK0019811 | River Spey SAC | Atlantic salmon, freshwater pearl mussel, and sea lamprey | Construction | Underwater noise generated during piling and UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Effects due to EMFs from subsea electrical cabling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| UK0030088 | Berriedale and Langwell Waters SAC | Atlantic salmon | Construction | Underwater noise generated during piling and UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Effects due to EMFs from subsea electrical cabling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| UK0030263 | River Teith SAC | Atlantic salmon and sea lamprey | Construction | Underwater noise generated during piling and UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Effects due to EMFs from subsea electrical cabling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| UK0030261 | River Oykel SAC | Atlantic salmon and freshwater pearl mussel | Construction | Underwater noise generated during piling and UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Effects due to EMFs from subsea electrical cabling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |

| Site ID | Site Name | Relevant Qualifying Features | Project Phase | Potential Impact | Conclusion for the Assessment on the Array Alone | Conclusion for the Assessment on the Array In-Combination with other Plans and Projects |
|---|---|---|---|---|---|---|
| **Annex II Marine Mammals** | | | | | | |
| UK0017072 | Berwickshire and North Northumberland Coast SAC | Grey seal | Construction | Underwater noise generated during piling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Underwater noise generated during UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Injury and disturbance due to site-investigation surveys (including geophysical surveys)* | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Changes in prey availability | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Entanglement | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Injury and disturbance due to site-investigation surveys (including geophysical surveys)* | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| UK0030311 | Southern North Sea SAC | Harbour porpoise | Construction | Underwater noise generated during piling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Underwater noise generated during UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Injury and disturbance due to site-investigation surveys (including geophysical surveys)* | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Changes in prey availability | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Entanglement | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Injury and disturbance due to site-investigation surveys (including geophysical surveys)* | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |

| Site ID | Site Name | Relevant Qualifying Features | Project Phase | Potential Impact | Conclusion for the Assessment on the Array Alone | Conclusion for the Assessment on the Array In-Combination with other Plans and Projects |
|---|---|---|---|---|---|---|
| UK0019808 | Moray Firth SAC | Bottlenose dolphin | Construction | Underwater noise generated during piling | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Underwater noise generated during UXO clearance | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Injury and disturbance due to site-investigation surveys (including geophysical surveys)* | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Changes in prey availability | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | Operation and maintenance | Entanglement | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |
| | | | | Injury and disturbance due to site-investigation surveys (including geophysical surveys)* | No adverse effect on the integrity of the site | No adverse effect on the integrity of the site |

*It should be noted that only disturbance due to underwater noise generated during site-investigation surveys was assessed in the in-combination assessment, based on the low injury ranges modelled for the Array alone (see paragraph 895).

# 8. REFERENCES


Aarts, G., Brasseur, S. and Kirkwood, R. (2018). *Behavioural response of grey seals to pile driving.* Wageningen, Wageningen Marine Research (University & Research centre) pp.54.

Ailsa J, H., Bernie J, M. and Richard J, B. (2001). *Factors affecting first-year survival in grey seals and their implications for life history strategy*. Journal of Animal Ecology, 70 (1), pp.138-149. DOI:10.1111/j.1365-2656.2001.00468.x.

Akamatsu, T., Teilmann, J., Miller, L., Tougaard, J., Dietz, R., Wang, D., Wang, K., Siebert, U. and Naito, Y. (2007). *Comparison of echolocation behaviour between coastal and riverine porpoises.* pp.520-526.

Allen, R., Jarvis, D., Sayer, S. and Mills, C. (2012). *Entanglement of grey seals Halichoerus grypus at a haul out site in Cornwall, UK*. Marine Pollution Bulletin, 64 (12), pp.2815-2819. DOI:https://doi.org/10.1016/j.marpolbul.2012.09.005.

Andersen, S. M., Teilmann, J., Dietz, R., Schmidt, N. M. and Miller, L. A. (2012). *Behavioural responses of harbour seals to human-induced disturbances*. Aquatic Conservation: Marine and Freshwater Ecosystems, 22 (1), pp.113-121. DOI:10.1002/aqc.1244.

Armstrong, D., Hunter, D.-C., Fryer, R. J., Rycroft, P. and Orpwood, J. E. (2015). *Behavioural responses of Atlantic Salmon to mains frequency magnetic fields.* Scottish Marine and Freshwater Science. Marine Scotland. Document Number 9.

Arso Civil, M., Quick, N., Mews, S., Hague, E., Cheney, B. J., Thompson, P. M. and Hammond, P. S. (2021). *Improving understanding of bottlenose dolphin movements along the east coast of Scotland. Final report.* Report number SMRUC-VAT-2020-10 provided to European Offshore Wind Deployment Centre (EOWDC) pp.15.

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), pp.178-196. DOI:10.1002/aqc.3102.

Au, W. W. L., Floyd, R. W., Penner, R. H. and Murchison, A. E. (1974). *Measurement of echolocation signals of the Atlantic bottlenose dolphin, Tursiops truncatus Montagu, in open waters*. The Journal of the Acoustical Society of America, 56 (4), pp.1280-1290.

Bagočius, D. (2015). *Piling underwater noise impact on migrating salmon fish during Lithuanian LNG terminal construction (Curonian Lagoon, Eastern Baltic Sea Coast)*. Marine Pollution Bulletin, 92 (1-2), pp.45-51.

Bailey, H., Senior, B., Simmons, D., Rusin, J., Picken, G. and Thompson, P. M. (2010). *Assessing underwater noise levels during pile-driving at an offshore windfarm and its potential effects on marine mammals*. Marine Pollution Bulletin, 60 (6), pp.888-897. DOI:https://doi.org/10.1016/j.marpolbul.2010.01.003.

Beatrice Offshore Wind Farm Limited. (2018). *Beatrice Offshore Wind Farm - Piling Strategy Implementation Report.* Document Number LF000005-REP-2397 Rev1.0.

Beatrice Offshore Wind Farm Limited. (2021a). *Post-construction Cod Spawning Survey – Technical Report.* Beatrice Offshore Windfarm

Beatrice Offshore Wind Farm Limited. (2021b). *Post-construction Sandeel Survey – Technical Report.* Beatrice Offshore Wind Farm pp.123.

Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R., Heithaus, M., Watson-Capps, J., Flaherty, C. and Krützen, M. (2006). *Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance*. Conservation Biology, 20 (6), pp.1791-1798.

Benhemma-Le Gall, A., Graham, I. M., Merchant, N. D. and Thompson, P. M. (2021). *Broad-Scale Responses of Harbor Porpoises to Pile-Driving and Vessel Activities During Offshore Windfarm Construction*. Frontiers in Marine Science, 8. DOI:10.3389/fmars.2021.664724.

Benjamins, S., Harnois, V., Smith, H. C. M., Johanning, L., Greenhill, L., Carter, C. and Wilson, B. (2014). *Understanding the potential for marine megafauna entanglement risk from marine renewable energy developments.* Scottish Natural Heritage. Perth, Scotland. Document Number Scottish Natural Heritage Commissioned Report No. 791.

Bjørge, A. and Tolley, K. A. (2009). *Harbor Porpoise: Phocoena phocoena*. *In:* Perrin, W. F., Würsig, B. and Thewissen, J. G. M. (eds.) *Encyclopedia of Marine Mammals (Second Edition).* London: Academic Press.

Bodznick, D. and Northcutt, R. G. (1981). *Electroreception in lampreys: evidence that the earliest vertebrates were electroreceptive*. Science, 212 (4493), pp.465-7. DOI:10.1126/science.7209544.

Bodznick, D. and Preston, D. G. (1983). *Physiological characterization of electroreceptors in the lampreys Ichthyomyzon unicuspis and Petromyzon marinus*. Journal of Comparative Physiology, 152 (2), pp.209-217. DOI:10.1007/BF00611185.

Booth, C. G. (2019). *Food for thought: Harbor porpoise foraging behavior and diet inform vulnerability to disturbance*. Marine Mammal Science, 36 (1), pp.195-208. DOI:10.1111/mms.12632.

Brandt, M., Hoeschle, C., Diederichs, A., Betke, K., Matuschek, R., Witte, S. and Nehls, G. (2013). *Far-reaching effects of a seal scarer on harbour porpoises, Phocoena phocoena*. Aquatic Conservation Marine and Freshwater Ecosystems, 23, pp.222-232. DOI:10.1002/aqc.2311.

Brandt, M. J., Diederichs, A., Betke, K. and Nehls, G. (2011). *Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea*. Marine Ecology Progress Series, 421, pp.205-216. DOI:10.3354/meps08888.

Brandt, M. J., Dragon, A. C., Diederichs, A., Bellmann, M. A., Wahl, V., Piper, W., Nabe-Nielsen, J. and Nehls, G. (2018). *Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany*. Marine Ecology Progress Series, 596, pp.213-232. DOI:10.3354/meps12560.

Broadshore Offshore Wind Farm Limited, Sinclair Offshore Wind Farm Limited and Scaraben Offshore Wind Farm Limited. (2024). *Broadshore Hub Wind Farm Development Areas Scoping Report.* Document Number BFR_HUB_CST_REP_0002. pp.760.

Buchan Offshore Wind Limited. (2023). *Buchan Offshore Wind Offshore Scoping Report.* pp.542.

Burns, R. D. J., Martin, S. B., Wood, M. A., Wilson, C. C., Lumsden, C. E. and Pace, F. (2022). *Hywind Scotland Floating Offshore Wind Farm: Sound Source Characterisation of Operational Floating Turbines.* Technical report by JASCO Applied Sciences for Equinor Energy AS. Document Number Document 02521, Version 3.0 FINAL. pp.82.

Campbell, R. N. B. (2013). *Tweed Estuary SAC lamprey assessment 2013 Report.* The Tweed Foundation

Carter, M. I. D., Boehme, L., Cronin, M. A., Duck, C. D., Grecian, W. J., Hastie, G. D., Jessopp, M., Matthiopoulos, J., McConnell, B. J., Miller, D. L., Morris, C. D., Moss, S. E. W., Thompson, D., Thompson, P. M. and Russell, D. J. F. (2022). *Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management*. Frontiers in Marine Science, 9, pp.18. DOI:10.3389/fmars.2022.875869.

Carter, M. I. D., Boehme, L., Duck, C. D., Grecian, W. J., Hastie, G. D., McConnell, B. J., Miller, D. L., Morris, C. D., Moss, S. E. W., Thompson, D., Thompson, P. M. and Russell, D. J. F. (2020). *Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles.* Sea Mammal Research Unit, University of St Andrews pp.74.

Chapman, E. C. N., Rochas, C. M. V., Piper, A. J. R., Vad, J. and Kazanidis, G. (2023). *Effect of electromagnetic fields from renewable energy subsea power cables on righting reflex and physiological response of coastal invertebrates*. Marine Pollution Bulletin, 193, pp.115250. DOI:https://doi.org/10.1016/j.marpolbul.2023.115250.

Cheney, B., Graham, I. M., Barton, T., Hammond, P. S. and Thompson, P. M. (2018). *Site Condition Monitoring of bottlenose dolphins within the Moray Firth Special Area of Conservation: 2014-2016.* Scottish National Heritage. Document Number Research Report No 1021. pp.40.

Christiansen, F. and Lusseau, D. (2015). *Linking Behavior to Vital Rates to Measure the Effects of Non-Lethal Disturbance on Wildlife*. Conservation Letters, 8 (6), pp.424-431. DOI:10.1111/conl.12166.

Chung-Davidson, Y.-W., Bryan, M. B., Teeter, J., Bedore, C. N. and Li, W. (2008). *Neuroendocrine and behavioral responses to weak electric fields in adult sea lampreys (Petromyzon marinus)*. Hormones and Behaviour, 54 (1), pp.34-40.

Clarke Murray, C., Mach, M. and Martone, R. (2014). *Cumulative Effects in Marine Ecosystems: Scientific Perspectives on its Challenges and Solutions.* WWF-Canada and Center For Ocean Solutions pp.60.

Clavelle, T., Lester, S. E., Gentry, R. and Froehlich, H. E. (2019). *Interactions and management for the future of marine aquaculture and capture fisheries*. Fish and Fisheries, 20 (2), pp.368-388. DOI:10.1111/faf.12351.

CMACS. (2003). *A baseline assessment of electromagnetic fields generated by offshore windfarm cables.* CMACS

Copping, A. E., Hemery, L. G., Overhus, D. M., Garavelli, L., Freeman, M. C., Whiting, J. M., Gorton, A. M., Farr, H. K., Rose, D. J. and Tugade, L. G. (2020). *Potential Environmental Effects of Marine Renewable Energy Development—The State of the Science*. Journal of Marine Science and Engineering, 8 (11), pp.879.

Costa, D. P. (2012). *A bioenergetics approach to developing a population consequences of acoustic disturbance model*. *The effects of noise on aquatic life.* Springer.

Coull, K., Johnstone, R. and Rogers, S. (1998). *Fisheries sensitivity maps in British waters.* Published and distributed by UKOOA Ltd pp.63.

Cox, T. M., Ragen, T., Read, A., Vos, E., Baird, R. W., Balcomb, K., Barlow, J., Caldwell, J., Cranford, T. and Crum, L. (2006). *Understanding the impacts of anthropogenic sound on beaked whales.* Space and Naval Warfare Systems Center San Diego Ca

Cox, T. M. and Read, A. J. (2004). *Echolocation behavior of harbor porpoises Phocoena phocoena around chemically enhanced gill nets*. Marine Ecology Progress Series, 279, pp.275-282.

CSA Ocean Sciences Inc and Exponent. (2019). *Evaluation of Potential EMF Effects on Fish Species of Commercial or Recreational Fishing Importance in Southern New England.* Bureau of Ocean Energy Management. Virginia, USA pp.59 pp.

Dähne, M., Tougaard, J., Carstensen, J., Rose, A. and Nabe-Nielsen, J. (2017). *Bubble curtains attenuate noise from offshore wind farm construction and reduce temporary habitat loss for harbour porpoises*. Marine Ecology Progress Series, 580, pp.221-237.

Damseaux, F., Siebert, U., Pomeroy, P., Lepoint, G. and Das, K. (2021). *Habitat and resource segregation of two sympatric seals in the North Sea*. Sci Total Environ, 764, pp.142842. DOI:10.1016/j.scitotenv.2020.142842.

Deecke, V. B., Slater, P. J. and Ford, J. K. (2002). *Selective habituation shapes acoustic predator recognition in harbour seals*. Nature, 420 (6912), pp.171-173.

Dehnhardt, G., Mauck, B., Hanke, W. and Bleckmann, H. (2001). *Hydrodynamic Trail-Following in Harbor Seals (<i>Phoca vitulina</i>)*. Science, 293 (5527), pp.102-104. DOI:doi:10.1126/science.1060514.

Dyndo, M., Wisniewska, D. M., Rojano-Donate, L. and Madsen, P. T. (2015). *Harbour porpoises react to low levels of high frequency vessel noise*. Scientific Reports, 5, pp.11083. DOI:10.1038/srep11083.

ElectroMagneticWorks Inc. (2022). *3 phase high voltage submarine power cables and their impact on marine ecosystem – How EM Simulation can help engineers design eco-friendly power transmission cables* [Online]. Available at: https://www.emworks.com/blog/high-voltage/3-phase-high-voltage-submarine-power-cables. Accessed on: February 2024.

Ellis, J., Milligan, S., Readdy, L., Taylor, N. and Brown, M. (2012). *Spawning and nursery grounds of selected fish species in UK waters, Centre for Environment Fisheries and Aquaculture Science (CEFAS).* CEFAS Science Series Technical Report pp.56.

Ellison, W. T., Southall, B. L., Clark, C. W. and Frankel, A. S. (2012). *A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds*. Conserv Biol, 26 (1), pp.21-8. DOI:10.1111/j.1523-1739.2011.01803.x.

Embling, C. B., Gillibrand, P. A., Gordon, J., Shrimpton, J., Stevick, P. T. and Hammond, P. S. (2010). *Using habitat models to identify suitable sites for marine protected areas for harbour porpoises (Phocoena phocoena)*. Biological Conservation, 143 (2), pp.267-279. DOI:10.1016/j.biocon.2009.09.005.

Erbe, C., Dunlop, R. and Dolman, S. (2018). *Effects of Noise on Marine Mammals*. *Springer Handbook of Auditory Research.*

Farcas, A., Powell, C. F., Brookes, K. L. and Merchant, N. D. (2020). *Validated shipping noise maps of the Northeast Atlantic*. Science of The Total Environment, 735, pp.139509. DOI:10.1016/j.scitotenv.2020.139509.

Fernandez-Betelu, O., Graham, I. M., Brookes, K. L., Cheney, B. J., Barton, T. R. and Thompson, P. M. (2021). *Far-field effects of impulsive noise on coastal bottlenose dolphins*. Frontiers in Marine Science, 8, pp.664230.

Finneran, J. J. (2015). *Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015*. Journal of the Acoustical Society of America, 138 (3), pp.1702-26. DOI:10.1121/1.4927418.

Finneran, J. J. and Schlundt, C. E. (2013). *Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (Tursiops truncatus)*. The Journal of the Acoustical Society of America, 133 (3), pp.1819-1826.

Finneran, J. J., Schlundt, C. E., Carder, D. A., Clark, J. A., Young, J. A., Gaspin, J. B. and Ridgway, S. H. (2000). *Auditory and behavioral responses of bottlenose dolphins (Tursiops truncatus) and a beluga whale (Delphinapterus leucas) to impulsive sounds resembling distant signatures of underwater explosions*. Journal of the Acoustical Society of America, 108, pp.417-438.

Flotation Energy. (2023). *Cenos Offshore Windfarm Scoping Report.* pp.174.

Forewind. (2014). *Chapter 14 Marine Mammals.* Environmental Statement. Dogger Bank Teeside A & B pp.285pp.

Fred Olsen Seawind and Vattenfall. (2023). *Muir Mhor Offshore Environmental Impact Assessment (EIA) Scoping Report.*

Fujita, R., Brittingham, P., Cao, L., Froehlich, H., Thompson, M. and Voorhees, T. (2023). *Toward an environmentally responsible offshore aquaculture industry in the United States: Ecological risks, remedies, and knowledge gaps*. Marine Policy, 147, pp.105351. DOI:10.1016/j.marpol.2022.105351.

Gannon, D., Nowacek, D., Read, A., Waples, D. and Wells, R. (2005). *Prey detection by bottlenose dolphins, Tursiops truncatus: An experimental test of the passive listening hypothesis*. Animal Behaviour, 69, pp.709-720. DOI:10.1016/j.anbehav.2004.06.020.

Garavelli, L. (2020). *2020 State of the Science Report-Chapter 8: Encounters of Marine Animals with Marine Renewable Energy Device Mooring Systems and Subsea Cables*.

Gardiner, R., Main, R., Davies, I., Kynoch, R., Gilbey, J., Adams, C. and M., N. (2018a). *Recent investigations into the marine migration of salmon smolts in the context of marine renewable development. Conference Presentation*. *Environmental Interactions of Marine Renewables (EIMR) Conference.* Kirkwall, Orkney.

Gardiner, R., Main, R., Kynoch, R., Gilbey, J. and Davies, I. (2018b). *A needle in the haystack? Seeking salmon smolt migration routes off the Scottish east coast using surface trawling and genetic assignment. Poster presentation to the MASTS Annual Science Meeting 31 October – 2 November 2018.*

Gauld, N. R. (2014). *The behavioural ecology of migratory salmonids in the River Tweed, UK.* Doctor of Philosophy, Durham University.

Gauld, N. R., Campbell, R. N. B. and Lucas, M. C. (2016). *Salmon and sea trout spawning migration in the River Tweed: telemetry-derived insights for management*. Hydrobiologia, 767 (1), pp.111-123. DOI:10.1007/s10750-015-2481-0.

Geelhoed, S. C. V., Authier, M., Pigeault, R. and Gilles, A. (2022). *Abundance and distribution of cetaceans. In: OSPAR (2023): The 2023 Quality Status Report for the Northeast Atlantic* [Online]. London: OSPAR Commission. Available at: https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/indicator-assessments/abundance-distribution-cetaceans/. Accessed on: November 2023.

Gill, A. B. and Bartlett, M. (2010). *Literature review on the potential effects of electromagnetic fields and subsea noise from marine renewable energy developments on Atlantic salmon, sea trout and European eel.* Scottish Natural Heritage. Inverness, Scotland

Gill, A. B., Gloyne-Phillips, I., Neal, K. J. and Kimber, J. A. (2005). *The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms – a review.* COWRIE 1.5 Electomagnetic Fields Review. Cranfield University and CMACS

Gill, A. B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J. and Wearmouth, V. (2009). *COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF-sensitive fish response to EM emissions from sub-sea electricity cables of the type used by the offshore renewable energy industry.* Commissioned by COWRIE Ltd (project reference COWRIE-EMF-1-06)

Gill, J. A., Norris, K. and Sutherland, W. J. (2001). *Why behavioural responses may not reflect the population consequences of human disturbance*. Biological Conservation, 97 (2), pp.265-268.

Gilles, A., Authier, M., Ramirez-Martinez, N. C., Araújo, H., Blanchard, A., Carlström, J., Eira, C., Dorémus, G., Fernández-Maldonado, C., Geelhoed, S. C. V., Kyhn, L., Laran, S., Nachtsheim, D., Panigada, S., Pigeault, R., Sequeira, M., Sveegaard, S., Taylor, N. L., Owen, K., Saavedra, C., Vázquez-Bonales, J. A., Unger, B. and Hammond, P. S. (2023). *Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys.* Final report published 29 September 2023 pp.64.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R. and Thompson, D. (2003). *A Review of the Effects of Seismic Surveys on Marine Mammals*. Marine Technology Society Journal, 37 (4), pp.16-34. DOI:10.4031/002533203787536998.

Gosch, M. (2017). *The diet of the grey seal [Halichoerus grypus (Fabricius, 1791)] in Ireland and potential interactions with commercial fisheries.*

Graham, I. M., Merchant, N. D., Farcas, A., Barton, T. R., Cheney, B., Bono, S. and Thompson, P. M. (2019). *Harbour porpoise responses to pile-driving diminish over time*. Royal Society Open Science, 6 (6), pp.190335. DOI:doi:10.1098/rsos.190335.

Graham, I. M., Pirotta, E., Merchant, N. D., Farcas, A., Barton, T. R., Cheney, B., Hastie, G. D. and Thompson, P. M. (2017). *Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction*. Ecosphere, 8 (5), pp.e01793. DOI:10.1002/ecs2.1793.

GreenVolt. (2023). *Green Volt Offshore Windfarm Offshore EIA Report.* pp.232.

Grellier, K. and Lacey, C. (2011). *Analysis of The Crown Estate aerial survey data for marine mammals for the Forth and Tay Offshore Wind Developers Group region.* Unpublished report to The FTOWDG. Document Number SMRUL-SGW-2012-015.

Hall, A. and Thompson, D. (2009). *Gray Seal: Halichoerus grypus*. *In:* Perrin, W. F., Würsig, B. and Thewissen, J. G. M. (eds.) *Encyclopedia of Marine Mammals (Second Edition).* London: Academic Press.

Halvorsen, M. B., Casper, B. M., Matthews, F., Carlson, T. J. and Popper, A. N. (2012a). *Effects of exposure to pile-driving sounds on the lake sturgeon, Nile tilapia and hogchoker*. Proceedings of the Royal Society B, 279 (1748), pp.4705-14. DOI:10.1098/rspb.2012.1544.

Halvorsen, M. B., Casper, B. M., Woodley, C. M., Carlson, T. J. and Popper, A. N. (2011). *Predicting and mitigating hydroacoustic impacts on fish from pile installations*. *National Cooperative Highway Research Program 363.* Transportation Research Board, National Academy of Sciences, Washington, D.C.

Halvorsen, M. B., Casper, B. M., Woodley, C. M., Carlson, T. J. and Popper, A. N. (2012b). *Threshold for Onset of Injury in Chinook Salmon from Exposure to Impulsive Pile Driving Sounds*. PLoS ONE, 7 (6), pp.e38968. DOI:10.1371/journal.pone.0038968.

Hammond, P. S., C. Lacey, A. Gilles, S. Viquerat, P. Börjesson, H. Herr, K. Macleod, V. Ridoux, M. Santos, M. Scheidat, J. Teilmann, J. Vingada and N. Øien. (2021). *Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. Revised June 2021.* pp.42.

Hammond, P. S., Northridge, S. P., Thompson, D., Gordon, J. C. D., Hall, A. J., Aarts, G. and Matthiopoulos, J. (2005). *Background information on marine mammals for Strategic Environmental Assessment 6.* Sea Mammal Research Unit

Hanke, W. and Dehnhardt, G. (2013). *Sensory biology of aquatic mammals*. Journal of Comparative Physiology A, 199 (6), pp.417-420. DOI:10.1007/s00359-013-0823-9.

Hansen, L. P. and Quinn, T. P. (1998). *The marine phase of the Atlantic salmon (Salmo salar) life cycle, with comparisons to Pacific salmon*. Canadian Journal of Fisheries and Aquatic Sciences, 55 (S1), pp.104-118. DOI:10.1139/d98-010.

Harding, H., Bruintjes, R., Radford, A. N. and Simpson, S. D. (2016). *Measurement of Hearing in the Atlantic salmon (Salmo salar) using Auditory Evoked Potentials, and effects of Pile Driving Playback on salmon Behaviour and Physiology.* Scottish Marine and Freshwater Science Vol 7 No 11. Marine Scotland Science pp.51.

Harnois, V., Smith, H. C. M., Benjamins, S. and Johanning, L. (2015). *Assessment of entanglement risk to marine megafauna due to offshore renewable energy mooring systems.* University of Exeter and SAMS

Harwood, J., Booth, C., Sinclair, R. and Hague, E. (2020). *Developing marine mammal Dynamic Energy Budget models and their potential for integration into the iPCoD framework.* Scottish Marine and Freshwater Science Volume 11 Number 11. Marine Scotland Science

Hasler, A. D. and Scholz, A. T. (1983). *Olfactory imprinting and homing in salmon. Investigations in the mechanism of the imprinting process.* Berlin Heidelberg: Springer.

Hastie, G., Merchant, N. D., Götz, T., Russell, D. J., Thompson, P. and Janik, V. M. (2019). *Effects of impulsive noise on marine mammals: investigating range-dependent risk*. Ecological Applications, 29 (5), pp.e01906.

Hastie, G. D., Lepper, P., McKnight, J. C., Milne, R., Russell, D. J. and Thompson, D. (2021). *Acoustic risk balancing by marine mammals: anthropogenic noise can influence the foraging decisions by seals*. Journal of Applied Ecology, 58 (9), pp.1854-1863.

Hastie, G. D., Russell, D. J. F., McConnell, B., Moss, S., Thompson, D. and Janik, V. M. (2015a). *Sound exposure in harbour seals during the installation of an offshore wind farm: predictions of auditory damage*. Journal of Applied Ecology, 52 (3), pp.631-640. DOI:10.1111/1365-2664.12403.

Hastie, G. D., Russell, D. J. F., McConnell, B., Moss, S., Thompson, D., Janik, V. M. and Punt, A. (2015b). *Sound exposure in harbour seals during the installation of an offshore wind farm: predictions of auditory damage*. Journal of Applied Ecology, 52 (3), pp.631-640. DOI:10.1111/1365-2664.12403.

Hastie, G. D., Wilson, B. E. N., Wilson, L. J., Parsons, K. M. and Thompson, P. M. (2004). *Functional mechanisms underlying cetacean distribution patterns: hotspots for bottlenose dolphins are linked to foraging*. Marine Biology, 144, pp.397-403.

Hastings, M. C. (2002). *Clarification of the Meaning of Sound Pressure Levels & the Known Effects of Sound on Fish.* White Paper.

Hayes, M. P. and Gough, P. T. (1992). *Broad-band synthetic aperture sonar*. IEEE Journal of Oceanic engineering, 17 (1), pp.80-94.

Hedger, R., Martin, F., Hatin, D., Caron, F., Whoriskey, F. and Dodson, J. (2008). *Active migration of wild Atlantic salmon Salmo salar smolt through a coastal embayment*. Marine Ecology Progress Series, 355, pp.235-246. DOI:10.3354/meps07239.

Heide-Jørgensen, M. P., Hansen, R. G., Westdal, K., Reeves, R. R. and Mosbech, A. (2013). *Narwhals and seismic exploration: Is seismic noise increasing the risk of ice entrapments?* Biological Conservation, 158, pp.50-54. DOI:10.1016/j.biocon.2012.08.005.

Hervé, L. (2021). *An evaluation of current practice and recommendations for environmental impact assessment of electromagnetic fields from offshore renewables on marine invertebrates and fish.* Erasmus Mundus Joint Master Degree Renewable Energy in the Marine Environment, University of Strathclyde.

Hindar, K., Hutchings, J. A., Diserud, O. H. and Fiske, P. (2011). *Chapter 12: Stock, recruitment and exploitation*. *In:* Aas, O., Einum, S., Klemetsen, A. and Skurdal, J. (eds.) *Atlantic Salmon Ecology.* West Sussex, England: Blackwell Publishing.

Huang, Y. (2005). *Electromagnetic Simulations of 135- kV Three phase Submarine Power Cables.* Centre for Marine and Coastal Studies, Ltd Prepared for Sweden Offshore.

Hume, J. B. (2017). *A review of the geographic distribution, status and conservation of Scotland's lampreys*. Glasgow Naturalist, 26**,** pp.1-10.

Hutchison, Z. L., Gill, A. B., Sigray, P., He, H. and King, J. W. (2021). *A modelling evaluation of electromagnetic fields emitted by buried subsea power cables and encountered by marine animals: considerations for marine renewable energy development*. Renewable Energy, 177**,** pp.72-81.

Hutchison, Z. L., Sigray, P., He, H., Gill, A. B., King, J. and Gibson, C. (2018). *Electromagnetic Field (EMF) Impacts on Elasmobranch (shark, rays, and skates) and American Lobster Movement and Migration from Direct Current Cables.* U.S. Department of the Interior, Bureau of Ocean Energy Management. Virginia, USA

IAMMWG. (2015). *Management Units for cetaceans in UK waters (January 2015).* JNCC Report No. 547. Peterborough pp.42.

IAMMWG. (2022). *Updated abundance estimates for cetacean Management Units in UK waters.* JNCC Report No. 680 (Revised March 2022). JNCC. Peterborough. Document Number 0963-8091. pp.22.

IAMMWG. (2023). *Review of Management Unit boundaries for cetaceans in UK waters.* JNCC. Peterborough, UK pp.23.

Inch Cape Offshore Limited. (2018). *Offshore Environmental Impact Assessment. Chapter 10 - Marine Mammals.*

Isaacman, L. and Daborn, G. (2011). *Pathways of Effects for Offshore Renewable Energy in Canada.* Acadia Centre for Estuarine Research (ACER) Publication No. 102. Wolfville, NS, Canada. Acadia University pp.70.

JNCC. (2010a). *JNCC guidelines for minimising the risk of injury to marine mammals from using explosives.* Joint Nature Conservation Committee. Aberdeen, Scotland pp.10.

JNCC. (2010b). *The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area.*

JNCC. (2010c). *Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise.* Joint Nature Conservation Committee. Aberdeen, Scotland pp.13.

JNCC. (2015). *Natura 2000 - Standard Data Form. River Teith Site UK0030263.* JNCC pp.13.

JNCC. (2017). *JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys.* Joint Nature Conservation Committee. Aberdeen, Scotland pp.28.

JNCC. (2020). *Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England Wales and Northern Ireland).* JNCC. Peterborough. Document Number 654.

JNCC. (2021c). *JNCC guidelines for minimising the risk of disturbance and injury to marine mammals whilst using explosives* [Online]. Available at: https://hub.jncc.gov.uk/assets/24cc180d-4030-49dd-8977-a04ebe0d7aca. Accessed on: 17/11/2023.

JNCC. (2023a). *DRAFT guidelines for minimising the risk of injury to marine mammals from unexploded ordnance clearance in the marine environment.* Marine mammals and offshore industries pp.16.

JNCC. (2023b). *The Moray Firth SAC* [Online]. Available at: https://sac.jncc.gov.uk/site/UK0019808. Accessed on: February 2024.

JNCC. (2023c). *Sea lamprey Petromyzon marinus* [Online]. Available at: https://sac.jncc.gov.uk/species/S1095/. Accessed on: February 2024.

JNCC. (2023d). *Southern North Sea SAC* [Online]. Available at: https://jncc.gov.uk/our-work/southern-north-sea-mpa/. Accessed on: February 2024.

JNCC. (2024a). *Berriedale and Langwell Waters Designated Special Area of Conservation (SAC)* [Online]. Available at: https://sac.jncc.gov.uk/site/UK0030088. Accessed on: February 2024.

JNCC. (2024b). *Berwickshire and North Northumberland Coast SAC* [Online]. Available at: https://sac.jncc.gov.uk/site/UK0017072. Accessed on: February 2024.

JNCC. (2024c). *A complete list of SACs in the United Kingdom* [Online]. Available at: https://sac.jncc.gov.uk/site/. Accessed on: 14 May 2024.

JNCC. (2024d). *Freshwater pearl mussel Margaritifera margaritifera* [Online]. Available at: https://sac.jncc.gov.uk/species/S1029/. Accessed on: February 2024.

JNCC. (2024e). *Number 1106 Atlantic salmon Salmo salar* [Online]. Available at: https://sac.jncc.gov.uk/species/S1106/. Accessed on: February 2024.

JNCC. (2024f). *River Oykel Designated Special Area of Conservation (SAC)* [Online]. Available at: https://sac.jncc.gov.uk/site/UK0030261. Accessed on: February 2024.

JNCC. (2024g). *River South Esk Designated Special Area of Conservation (SAC)* [Online]. Available at: https://sac.jncc.gov.uk/site/UK0030262. Accessed on: February 2024.

JNCC. (2024h). *River Spey Special Area of Conservation* [Online]. Available at: https://sac.jncc.gov.uk/site/UK0019811. Accessed on: February 2024.

JNCC. (2024i). *River Tay Designated Special Area of Conservation (SAC)* [Online]. Available at: https://sac.jncc.gov.uk/site/UK0030312. Accessed on: February 2024.

JNCC. (2024j). *River Teith Designated Special Area of Conservation (SAC)* [Online]. Available at: https://sac.jncc.gov.uk/site/UK0030263. Accessed on: February 2024.

JNCC. (2024k). *River Tweed Designated Special Area of Conservation (SAC)* [Online]. Available at: https://sac.jncc.gov.uk/site/UK0012691. Accessed on: February 2024.

JNCC and Natural England. (2019). *Harbour Porpoise (Phocoena phocoena) Special Area of Conservation: Southern North Sea. Conservation Objectives and Advice on Operations.* JNCC pp.29.

Jonsson, N., Hansen, L. P. and Jonsson, B. (1993). *Migratory behaviour and growth of hatchery-reared post-smolt Atlantic salmon Salmo salar*. Journal of Fish Biology, 42 (3)**,** pp.435-443.

Joy, R., Tollit, D., Wood, J., MacGillivray, A., Li, Z., Trounce, K. and Robinson, O. (2019). *Potential Benefits of Vessel Slowdowns on Endangered Southern Resident Killer Whales*. Frontiers in Marine Science, 6. DOI:10.3389/fmars.2019.00344.

Kastelein, R., de Haan, D. and Staal, C. (1995). *Entanglement of Harbour porpoises (Phocoena phocoena) in fishing nets*. In: Harbour porpoises - laboratory studies to reduce bycatch. Eds.: R E. Nachtigall, J. Lien, W.W.L. Au and A.J. Read, De Spil Publ., Woerden, 1995, pp. 91-156.

Kastelein, R., Hoek, L. and Jennings, N. (2018a). *Seasonal Changes in Food Consumption, Respiration Rate, and Body Condition of a Male Harbor Porpoise (Phocoena phocoena)*. Aquatic Mammals, 44**,** pp.76-91. DOI:10.1578/AM.44.1.2018.76.

Kastelein, R., Hoek, L., Jennings, N., Kester, R. and Huisman, R. (2019a). *Reduction in Body Mass and Blubber Thickness of Harbor Porpoises (Phocoena phocoena) Due to Near-Fasting for 24 Hours in Four Seasons*. Aquatic Mammals, 45**,** pp.37-47. DOI:10.1578/AM.45.1.2019.37.

Kastelein, R. A., Hardeman, J. and Boer, H. (1997). *Food consumption and body weight of harbour porpoises (Phocoena phocoena)*. *In:* Read, A. J., Wiepkema, P. R. and Nachtigall, P. E. (eds.) *The Biology of the Harbour Porpoise.* The Netherlands: De Spil Publishers.

Kastelein, R. A., Helder-Hoek, L., Booth, C., Jennings, N. and Leopold, M. (2019b). *High Levels of Food Intake in Harbor Porpoises (Phocoena phocoena): Insight into Recovery from Disturbance*. Aquatic Mammals, 45 (4)**,** pp.380-388. DOI:10.1578/am.45.4.2019.380.

Kastelein, R. A., Helder-Hoek, L., Cornelisse, S. A., Defillet, L. N., Huijser, L. A. and Gransier, R. (2021). *Temporary Hearing Threshold Shift in a Harbor Porpoise (Phocoena phocoena) Due to Exposure to a Continuous One-Sixth-Octave Noise Band Centered at 0.5 kHz*. Aquatic Mammals, 47 (2).

Kastelein, R. A., Helder-Hoek, L., Cornelisse, S. A., von Benda-Beckmann, A. M., Lam, F.-P. A., de Jong, C. A. and Ketten, D. R. (2020). *Lack of reproducibility of temporary hearing threshold shifts in a harbor porpoise after exposure to repeated airgun sounds*. The Journal of the Acoustical Society of America, 148 (2), pp.556-565.

Kastelein, R. A., Helder-Hoek, L., Kommeren, A., Covi, J. and Gransier, R. (2018b). *Effect of pile-driving sounds on harbor seal (Phoca vitulina) hearing*. The Journal of the Acoustical Society of America, 143 (6), pp.3583. DOI:10.1121/1.5040493.

Kastelein, R. A., Helder-Hoek, L. and Van De Voorde, S. (2017). *Hearing thresholds of a male and a female harbor porpoise (Phocoena phocoena)*. The Journal of the Acoustical Society of America, 142 (2), pp.1006-1010. DOI:10.1121/1.4997907.

Kastelein, R. A., Hoek, L., Gransier, R., Rambags, M. and Claeys, N. (2014). *Effect of level, duration, and inter-pulse interval of 1-2 kHz sonar signal exposures on harbor porpoise hearing*. J Acoust Soc Am, 136 (1), pp.412-22. DOI:10.1121/1.4883596.

Kastelein, R. A., van Heerden, D., Gransier, R. and Hoek, L. (2013). *Behavioral responses of a harbor porpoise (Phocoena phocoena) to playbacks of broadband pile driving sounds*. Marine Environmental Research, 92, pp.206-14. DOI:10.1016/j.marenvres.2013.09.020.

Kavet, R., Wyman, M. T. and Klimley, A. P. (2016). *Modeling Magnetic Fields from a DC Power Cable Buried Beneath San Francisco Bay Based on Empirical Measurements*. PLOS ONE, 11 (2), pp.e0148543. DOI:10.1371/journal.pone.0148543.

Kindt-Larsen, L., Glemarec, G., Berg, C. W., Königson, S., Kroner, A.-M., Søgaard, M. and Lusseau, D. (2023). *Knowing the fishery to know the bycatch: bias-corrected estimates of harbour porpoise bycatch in gillnet fisheries*. Proceedings of the Royal Society B: Biological Sciences, 290 (2002). DOI:10.1098/rspb.2022.2570.

Kirkwood, J. K., Bennett, P. M., Jepson, P. D., Kuiken, T., Simpson, V. R. and Baker, J. R. (1997). *Entanglement in fishing gear and other causes of death in cetaceans stranded on the coasts of England and Wales*. Veterinary Record, 141 (4), pp.94-98. DOI:https://doi.org/10.1136/vr.141.4.94.

Knowlton, A. R. and Kraus, S. D. (2020). *Mortality and serious injury of northern right whales (Eubalaena glacialis) in the western North Atlantic Ocean*. Journal of Cetacean Research and Management, pp.193-208.

Knowlton, A. R., Robbins, J., Landry, S., McKenna, H. A., Kraus, S. D. and Werner, T. B. (2016). *Effects of fishing rope strength on the severity of large whale entanglements*. Conservation Biology, 30 (2), pp.318-328. DOI:10.1111/cobi.12590.

Kyhn, L., Jørgensen, P. B., Carstensen, J., Bech, N., Tougaard, J., Dabelsteen, T. and Teilmann, J. (2015). *Pingers cause temporary habitat displacement of harbour porpoises (Phocoena phocoena L.)*. Marine Ecology Progress Series, 526. DOI:10.3354/meps11181.

Lacey, C., Gilles, A., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M. B., Scheidat, M., Teilmann, J., Sveegaard, S., Vingada, J., Viquerat, S., Øien, N. and Hammond, P. S. (2022). *Modelled density surfaces of cetaceans in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys.* SCANS-III project report 2. University of St Andrews. UK pp.31.

Lacy, R. C., Williams, R., Ashe, E., Balcomb III, K. C., Brent, L. J. N., Clark, C. W., Croft, D. P., Giles, D. A., MacDuffee, M. and Paquet, P. C. (2017). *Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans*. Scientific Reports, 7 (1), pp.14119. DOI:10.1038/s41598-017-14471-0.

Lambert, E. (2020). *The feeding ecology of the harbour porpoise Phocoena phocoena L. in a changing environment.* Thesis submitted in partial fulfillment for master's degree in Marine and Lacustrine Science and Management. Ascobans

Langton, R., Boulcott, P. and Wright, P. J. (2021). *A verified distribution model for the lesser sandeel Ammodytes marinus*. Marine Ecology Progress Series, 667 (1), pp.145-159. DOI:10.3354/meps13693.

Leaper, R., Calderan, S. and Cooke, J. (2015). *A Simulation Framework to Evaluate the Efficiency of Using Visual Observers to Reduce the Risk of Injury from Loud Sound Sources*. Aquatic Mammals, 41, pp.375-387. DOI:10.1578/AM.41.4.2015.375.

Leatherwood, S., Reeves, R. R., Perrin, W. F., Evans, W. E. and Hobbs, L. (1988). *Whales, dolphins, and porpoises of the eastern North Pacific and adjacent Arctic waters: A guide to their identification*.

Liu, F. (1973). *Snap loads in lifting and mooring cable systems induced by surface wave conditions.* Naval Civil Engineering Lab Port Hueneme Ca

Lockyer, C. (1995). *Investigation into the life history of the harbour porpoise in British Waters.*

Lockyer, C. (2013). *Harbour porpoises ( Phocoena phocoena ) in the North Atlantic: Biological parameters*. NAMMCO Scientific Publications, 5, pp.71. DOI:10.7557/3.2740.

Lucke, K., Siebert, U., Lepper, P. A. and Blanchet, M. A. (2009). *Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli*. Journal of the Acoustical Society of America, 125 (6), pp.4060-70. DOI:10.1121/1.3117443.

Mackay, A. I. (2011). *An investigation of factors related to the bycatch of small cetaceans in fishing gear.* A thesis submitted to the University of St Andrews st for the degree of Doctor of Philosophy University of St Andrews. Scottish Oceans Institute - Sea Mammal Research Unit

Mackenzie, M. L., Kidney, D. and Donovan, C. R. (2012). *Forth and Tay Offshore Wind Developers Group: Cetacean Survey Data Analysis Report*.

Madsen, P., Wahlberg, M., Tougaard, J., Lucke, K. and Tyack, P. (2006). *Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs*. Marine Ecology Progress Series, 309, pp.279-295. DOI:10.3354/meps309279.

Maitland, P. S. (2003). *Ecology of the River, Brook and Sea Lamprey Lampetra fluviatilis, Lampetra planeri and Petromyzon marinus.* Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature. Peterborough, UK. pp.54.

Malcolm, I. A., Godfrey, J. and Youngson, A. F. (2010). *Review of migratory routes and behaviour of atlantic salmon, sea trout and european eel in scotland's coastal environment: Implications for the development of marine renewables.* Scottish Marine and Freshwater Science. Marine Scotland Science. Thurso, Scotland. Document Number 14. pp.77.

Malcolm, I. A., P., M. C. and J., M. K. (2015). *Spatio-Temporal Variability in Scottish Smolt Emigration Times and Sizes.* Scottish Marine and Freshwater Science. Document Number Volume 6 Number 2. pp.19.

Marine Mammal Commission. (2007). *Marine Mammals and Noise A Sound Approach to Research And Management.* A Report to Congress from the Marine Mammal Commission

Marmo, B., Roberts, I., Buckingham, M. p., King, S. and Booth, C. (2013). *Modelling of Noise Effects of Operational Offshore Wind Turbines including noise transmission through various foundation types.* Scottish Government. Edinburgh, Scotland. Document Number 5.

Martin, B., MacDonnell, J., Vallarta, J., Lumsden, E. and Burns, R. (2011). *HYWIND Acoustic Measurement Report: Ambient Levels and HYWIND Signature.* Technical report for Statoil by JASCO Applied Sciences

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M. N., Penrose, J. D., Prince, R. I. T., Adhitya, A., Murdoch, J. and McCabe, K. (2000). *Marine seismic surveys— a study of environmental implications*. The APPEA Journal, 40 (1), pp.692. DOI:10.1071/aj99048.

McGarry, T., Boisseau, O., Stephenson, S. and Compton, R. (2017). *Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale (Balaenoptera acutorostrata), a Low Frequency Cetacean.* ORJIP Project 4, Phase 2. Prepared on behalf of The Carbon Trust. Document Number RPS Report EOR0692.

McGarry, T., De Silva, R., Canning, S., Mendes, S., Prior, A., Stephenson, S. and Wilson, J. (2022). *Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 4.0).* JNCC. Peterborough. Document Number JNCC Report No. 615.

MD-LOT. (2023). *Scoping Opinion for Ossian Array.* Marine Directorate – Licensing Operations Team. Edinburgh

Melcón, M. L., Cummins, A. J., Kerosky, S. M., Roche, L. K., Wiggins, S. M. and Hildebrand, J. A. (2012). *Blue Whales Respond to Anthropogenic Noise*. PLoS ONE, 7 (2), pp.e32681. DOI:10.1371/journal.pone.0032681.

Mellish, J.-A. E., Iverson, S. and Bowen, W. D. (1999). *Variation in Milk Production and Lactation Performance in Grey Seals and Consequences for Pup Growth and Weaning Characteristics*. Physiological and Biochemical Zoology, 72 (6), pp.677-690. DOI:10.1086/316708.

Mickle, M. F., Miehls, S. M., Johnson, N. S. and Higgs, D. M. (2018). *Hearing capabilities and behavioural response of sea lamprey (Petromyzon marinus) to low-frequency sounds*. Canadian Journal of Fisheries and Aquatic Sciences, 76 (9), pp.1541-1548. DOI:10.1139/cjfas-2018-0359.

Mitcheson, H. (2008). *Inter-birth interval estimation for a population of bottlenose dolphins (Tursiops truncatus): accounting for the effects of individual variation and changes over time*. University of St. Andrews, St. Andrews, pp.1-66.

Moore, A. and Riley, W. D. (2009). *Magnetic particles associated with the lateral line of the European eel Anguilla anguilla*. Journal of Fish Biology, 74 (7), pp.1629-1634. DOI:https://doi.org/10.1111/j.1095-8649.2009.02197.x.

Moore, M. J., Bogomolni, A., Bowman, R., Hamilton, P. K., Harry, C. T., Knowlton, A. R., Landry, S., Rotstein, D. S. and Touhey, K. (2006). *Fatally entangled right whales can die extremely slowly*. *OCEANS 2006.* IEEE.

Moorkens, E. (2011). *Margaritifera margaritifera (Europe assessment).* The IUCN Red List of Threatened Species. IUCN

Moray West OWF Limited. (2018c). *Chapter 9 Marine Mammal Ecology.* Moray Offshore Windfarm (West) Limited Environmental Impact Assessment Report. Moray West Offshore Windfarm

Morell, M., Ijsseldijk, L. L., Berends, A. J., Gröne, A., Siebert, U., Raverty, S. A., Shadwick, R. E. and Kik, M. J. L. (2021). *Evidence of hearing loss and unrelated toxoplasmosis in a free-ranging harbour porpoise (Phocoena phocoena)*. Animals, 11 (11), pp.3058.

Morven Offshore Wind Limited. (2023). *Morven Offshore Wind Array Project Environmental Impact Assessment Scoping Report.* EnBW and BP pp.365.

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 Technical Report

National Grid Electricity Transmission and Scottish Hydro Electric Transmission plc. (2022). *Eastern Green Link 2 - Marine Scheme Environmental Appraisal Report Volume 2, Chapter 8 - Benthic Ecology.* pp.47.

Natural England. (2018). *Natural England Conservation Advice for Marine Protected Areas. Tweed Estuary SAC* [Online]. Available at: https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0030292&SiteName=tweed&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&HasCA=1&NumMarineSeasonality=7&SiteNameDisplay=Tweed%20Estuary%20SAC. Accessed on: February 2024.

Natural England. (2020). *Natural England and NatureScot Conservation Advice for Marine Protected Areas Berwickshire and North Northumberland Coast SAC* [Online]. Natural England Designated Sites View. Available at: https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0017072&SiteName=berwickshire%20&SiteNameDisplay=Berwickshire%20and%20North%20Northumberland%20Coast%20SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=1&HasCA=1&NumMarineSeasonality=1&SiteNameDisplay=Berwickshire%20and%20North%20Northumberland%20Coast%20SAC#mmo. Accessed on: February 2024.

Natural England. (2022). *European Site Conservation Objectives: Supplementary advice on conserving and restoring site features. River Tweed Special Area of Conservation (SAC) Site Code: UK0012691.* Natural England pp.74.

Natural England. (2023a). *Berwickshire and North Northumberland Coast SAC Supplemenraty Advice* [Online]. Available at: https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK0017072&SiteName=berwickshire%20&SiteNameDisplay=Berwickshire+and+North+Northumberland+Coast+SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=1,1. Accessed on: February 2024.

Natural England. (2023b). *Tweed Estuary SAC Supplementary Advice* [Online]. Available at: https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK0030292&SiteName=tweed&SiteNameDisplay=Tweed+Estuary+SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=7. Accessed on: February 2024.

NatureScot. (2015). *Conservation Objectives for River Teith Special Area of Conservation.* NatureScot

NatureScot. (2020a). *Assessment of lamprey abundance and distribution in the River Tweed SAC/SSSI, 2004. Occurrence dataset* [Online]. Available at: https://doi.org/10.15468/vv63tu. Accessed on: February 2024.

NatureScot. (2020b). *Berriedale and Langwell Waters Special Area of Sonservation (SAC) Conservation Advice Package.* NatureScot pp.9.

NatureScot. (2020c). *River Dee Special Area of Conservation (SAC) Conservation Advice Package.* NatureScot pp.19.

NatureScot. (2020d). *River Oykel Special Area of Conservation (SAC) Conservation Advice Package.* NatureScot pp.13.

NatureScot. (2020e). *River South Esk Special Area of Conservation (SAC) Conservation Advice Package.* NatureScot pp.15.

NatureScot. (2020f). *River Spey Special Area of Conservation (SAC) Conservation Advice Package.* NatureScot pp.22.

NatureScot. (2020g). *River Tay Special Area of Conservation (SAC) Conservation Advice Package.* NatureScot pp.23.

NatureScot. (2020h). *River Tweed Special Srea of Conservation (SAC) Conservation Advice Package.* NatureScot pp.26.

NatureScot. (2021). *Conservation and Management Advice for the Moray Firth SAC.* NatureScot pp.37.

NatureScot. (2023a). *Atlantic Salmon* [Online]. Available at: https://www.nature.scot/plants-animals-and-fungi/fish/freshwater-fish/atlantic-salmon. Accessed on: February 2024.

NatureScot. (2023b). *Freshwater pearl mussel* [Online]. Available at: https://www.nature.scot/plants-animals-and-fungi/invertebrates/freshwater-invertebrates/freshwater-pearl-mussel. Accessed on: February 2024.

NatureScot. (2023c). *Lamprey* [Online]. Available at: https://www.nature.scot/plants-animals-and-fungi/fish/freshwater-fish/lamprey. Accessed on: February 2024.

NatureScot. (2024). *Berwickshire and North Northumberland Coast SAC* [Online]. Available at: https://sitelink.nature.scot/site/8207. Accessed on: February 2024.

Nedwell, J. R., Parvin, S. J., Edwards, B., Workman, R., Brooker, A. G. and Kynoch, J. E. (2007). *Measurement and interpretation of underwater noise during construction and operation of offshore windfarms in UK waters.* COWRIE. Document Number Report No. 544R0738. pp.85pp.

Nedwell, J. R., Turnpenny, A. W. H., Lovell, J. M. and Edwards, B. (2006). *An investigation into the effects of underwater piling noise on salmonids*. The Journal of the Acoustical Society of America, 120 (5), pp.2550-2554. DOI:10.1121/1.2335573.

Newton, M., Honkanen, H., Lothian, A. and Adams, C. (2019). *The Moray Firth Tracking Project – Marine Migrations of Atlantic Salmon (Salmo salar) Smolts*. *Proceedings of the 2019 SAMARCH Project: International Salmonid Coastal and Marine Telemetry Workshop.*

Newton, M., Main, R. and Adams, C. (2017). *Atlantic Salmon Salmo Salar smolt movements in the Cromarty and Moray Firths, Scotland.* Beatrice Offshore Wind Farm pp.46.

Nielsen, N. H., Hansen, R. G., Teilmann, J. and Heide-Jørgensen, M. P. (2013). *Extensive offshore movements of harbour porpoises (Phocoena phocoena)*. *NAMMCO SC/20/HP/08 Harbour porpoise working group.*

NMFS. (2005). *Scoping Report for NMFS EIS for the National Acoustic Guidelines on Marine Mammals.* National Marine Fisheries Service

NMFS. (2016). *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing. Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts.* NOAA. Document Number Technical Memorandum NMFS-OPR-55. pp.178.

NMFS. (2018). *2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts.* U.S. Dept. of Commer., NOAA. Document Number NOAA Technical Memorandum NMFS-OPR-59. pp.167.

Nowacek, D. P., Thorne, L. H., Johnston, D. W. and Tyack, P. L. (2007). *Responses of cetaceans to anthropogenic noise*. Mammal Review, 37 (2), pp.81-115.

NRW. (2023). *NRW's Position on assessing behavioural disturbance of harbour porpoise (Phocoena phocoena) from underwater noise. Position statement.* NRW. Document Number Version 1.0.

Ocean Winds. (2022). *Caledonia Offshore Wind Farm Offshore Scoping Report.* Caledonia Offshore Wind Farm pp.444.

Ohman, M. C., Sigray, P. and Westerberg, H. (2007). *Offshore windmills and the effects of electromagnetic fields on fish*. Ambio, 36 (8), pp.630-3. DOI:10.1579/0044-7447(2007)36[630:owateo]2.0.co;2.

Olesiuk, P. F., Nichol, L. M., Sowden, M. J. and Ford, J. K. B. (2002). *Effect of the sound generated by an acoustic harrassment device on the relative abundance and distribution of harbour porpoises (Phocoena phocoena) in retreat passage, British Columbia*. Marine Mammal Science, 18 (4), pp.843-862. DOI:https://doi.org/10.1111/j.1748-7692.2002.tb01077.x.

Ordtek. (2022). *Project UXO Hazard Assessment: E1 East Offshore Wind Farm. Ordtek report reference: JM7048_UXO_DTS_HA_V1.0.*

ORJIP Ocean Energy. (2022). *Information Note: Encounters of Marine Animals with Mooring Systems and Subsea Cables.* Report to Welsh Government. ORJIP, pp.19.

Ørsted. (2018a). *Environmental Statement: Volume 2, Chapter 4 – Marine Mammals.* Hornsea Project Three Offshore Wind Farm

Ørsted. (2018b). *Report to Inform Appropriate Assessment.* Hornsea Three Offshore Wind Farm. Habitats Regulations Assessment pp.357.

Ørsted. (2021). *Hornsea Project Four: Environmental Statement (ES) PINS Document Reference: A2.4 APFP Regulation 5(2)(a) Volume A2, Chapter 4: Marine Mammals.*

OSPAR Commission. (2024). *Status Assessment 2022 - Atlantic salmon* [Online]. Available at: https://oap.ospar.org/en/ospar-assessments/committee-assessments/biodiversity-committee/status-assesments/atlantic-salmon/. Accessed on: February 2024.

Ossian OWFL. (2023). *Ossian Array EIA Scoping Report.* Ossian pp.353.

Ossian OWFL. (2024). *Array Environmental Impact Assessment.*

Otani, S., Naito, Y., Kato, A. and Kawamura, A. (2000). *Diving behavior and swimming speed of a free-ranging harbor porpoise, Phocoena phocoena*. Marine Mammal Science, 16 (4), pp.811-814.

Palmer, K., Brookes, K., Davies, I., Edwards, E. and Rendell, L. (2019). *Habitat use of a coastal delphinid population investigated using passive acoustic monitoring*. Aquatic Conservation: Marine and Freshwater Ecosystems, 29, pp.254-270. DOI:10.1002/aqc.3166.

Parsons, E. C. M., Dolman, S. J., Jasny, M., Rose, N. A., Simmonds, M. P. and Wright, A. J. (2009). *A critique of the UK's JNCC seismic survey guidelines for minimising acoustic disturbance to marine mammals: Best practise?* Marine Pollution Bulletin, 58 (5), pp.643-651. DOI:https://doi.org/10.1016/j.marpolbul.2009.02.024.

Parsons, E. C. M., Dolman, S. J., Wright, A. J., Rose, N. A. and Burns, W. C. G. (2008). *Navy sonar and cetaceans: Just how much does the gun need to smoke before we act?* Marine Pollution Bulletin, 56 (7), pp.1248-1257. DOI:https://doi.org/10.1016/j.marpolbul.2008.04.025.

Paxton, C. G. M., Scott-Hayward, L. A. S., MacKenzie, M. L., Rexstad, E. and Thomas, L. J. (2016). *Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources with Advisory Note.* Joint Nature Conservation Committee.

Pearson, W. H., Skalski, J. R. and Malme, C. I. (1992). *Effects of sounds from a geophysical survey device on behavior of captive rockfish (Sebastes spp.)*. Canadian Journal of Fisheries and Aquatic Sciences, 49 (7), pp.1343-1356.

Popper, A. (2005). *A Review of Hearing by Sturgeon and Lamprey.* U.S. Army Corps of Engineers, Portland District pp.23.

Popper, A., Hawkins, A., Fay, R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W., Gentry, R., Halvorsen, M., Løkkeborg, S., Rogers, P., Southall, B., Zeddies, D. and Tavolga, W. (2014). *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI.* Springer.

Popper, A. N. and Hoxter, B. (1987). *Sensory and nonsensory ciliated cells in the ear of the sea lamprey, Petromyzon marinus*. Brain, Behavior and Evolution, 30 (1-2), pp.43-61. DOI:10.1159/000118637.

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.* Document Number 14D/086.

Read, A. J., Drinker, P. and Northridge, S. (2006). *Bycatch of Marine Mammals in U.S. and Global Fisheries*. Conservation Biology, 20 (1), pp.163-169. DOI:https://doi.org/10.1111/j.1523-1739.2006.00338.x.

Read, A. J., Waples, D. M., Urian, K. W. and Swanner, D. (2003). *Fine-scale behaviour of bottlenose dolphins around gillnets*. Proc Biol Sci, 270 Suppl 1 (Suppl 1), pp.S90-2. DOI:10.1098/rsbl.2003.0021.

Reeves, R., McClellan, K. and Werner, T. (2013). *Marine mammal bycatch in gillnet and other entangling net fisheries, 1990 to 2011*. Endangered Species Research, 20 (1), pp.71-97. DOI:10.3354/esr00481.

Reichmuth, C., Sills, J. M., Mulsow, J. and Ghoul, A. (2019). *Long-term evidence of noise-induced permanent threshold shift in a harbor seal (<i>Phoca vitulina</i>)*. The Journal of the Acoustical Society of America, 146 (4), pp.2552-2561. DOI:10.1121/1.5129379.

Richardson, W. J., Malme, C. I., Green, J. C. R. and Thomson, D. H. (1995). *Marine mammals and noise.* San Diego, California, USA, Vol 1. Academic Press.

Risch, D., Favill, G., Marmo, B., van Geel, N., Benjamins, S., Thompson, P., Wittich, A. and Wilson, B. (2023a). *Characterisation of underwater operational noise of two types of floating offshore wind turbines.* Scottish Association for Marine Science and Xi Engineering Consultants pp.62.

Risch, D., Favill, G., Marmo, B., van Geel, N. C. F., Benjamins, S., Thompson, P., Wittich, A. and Wilson, B. (2023b). *Characterisation of underwater operational noise of two types of floating offshore wind turbines.* SAMS. Online pp.62.

River Dee Trust and MSS. (2023). *North East Scotland Salmon and Sea Trout Tracking Array.* Marine Scotland Science and the River Dee Trust pp.130.

Robertson, F. C. (2014). *Effects of seismic operations on bowhead whale behaviour: implications for distribution and abundance assessments.* University of British Columbia.

Robinson, K. P., Sim, T. M. C., Culloch, R. M., Bean, T. S., Cordoba Aguilar, I., Eisfeld, S. M., Filan, M., Haskins, G. N., Williams, G. and Pierce, G. J. (2017). *Female reproductive success and calf survival in a North Sea coastal bottlenose dolphin (Tursiops truncatus) population*. PLoS One, 12 (9), pp.e0185000.

Robinson, S. P., Wang, L., Cheong, S.-H., Lepper, P. A., Marubini, F. and Hartley, J. P. (2020). *Underwater acoustic characterisation of unexploded ordnance disposal using deflagration*. Marine Pollution Bulletin, 160, pp.111646.

Rogan, E., Breen, P., Mackey, M., Cañadas, A., Scheidat, M., Geelhoed, S. and Jessopp, M. (2018). *Aerial Surveys of Cetaceans and Seabirds in Irish waters: Occurrence, distribution and abundance in 2015-2017.*

Rojano-Doñate, L., McDonald, B. I., Wisniewska, D. M., Johnson, M., Teilmann, J., Wahlberg, M., Højer-Kristensen, J. and Madsen, P. T. (2018). *High field metabolic rates of wild harbour porpoises*. Journal of Experimental Biology, 221 (Pt 23). DOI:10.1242/jeb.185827.

Russell, D. J., Hastie, G. D., Thompson, D., Janik, V. M., Hammond, P. S., Scott-Hayward, L. A., 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, 53 (6), pp.1642-1652.

Russell, D. J. F. and Carter, M. I. D. (2021). *Estimating the proportion of grey seals hauled out during August surveys.* Sea Mammal Research Unit, University of St Andrews SCOS Briefing Paper 21/03

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 Government pp.30.

Russell, D. J. F. and Lonergan, M. (2012). *Short note on grey seal haul-out events at-sea.* NERC Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews. St Andrews

RWE Renewables UK. (2022). *Environmental Impact Assessment Scoping Report.* Dogger Bank South (West) and Dogger Bank South (East) pp.434.

Salomons, E. M., Binnerts, B., Betke, K. and von Benda-Beckmann, A. M. (2021). *Noise of underwater explosions in the North Sea. A comparison of experimental data and model predictions*. Journal of the Acoustical Society of America, 149 (3), pp.1878. DOI:10.1121/10.0003754.

Samarra, F. I. P., Borrell, A., Selbmann, A., Halldórson, S. D., Pampoulie, C., Chosson, V., Gunnlaugsson, T., Sigurðsson, G. M., Aguilar, A. and Víkingsson, G. A. (2022). *Insights into the trophic ecology of white-beaked dolphins Lagenorhynchus albirostris and harbour porpoises Phocoena phocoena in Iceland*. Marine Ecology Progress Series, 702, pp.139-152.

Santos, M. B. and Pierce, G. J. (2003). *The diet of harbour porpoise (Phocoena phocoena) in the northeast Atlantic: A review*. Oceanography and Marine Biology, An Annual Review, Volume 41, pp.363-369.

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 (Tursiops truncatus) in Scottish waters*. Journal of the Marine Biological Association of the United Kingdom, 81 (5), pp.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*. Frontiers in Marine Science, 6, pp.824.

Schulte-Pelkum, N., Wieskotten, S., Hanke, W., Dehnhardt, G. and Mauck, B. (2007). *Tracking of biogenic hydrodynamic trails in harbour seals (Phoca vitulina)*. Journal of Experimental Biology, 210 (5), pp.781-787. DOI:10.1242/jeb.02708.

SCOS. (2020). *Scientific Advice on Matters Related to the Management of Seal Populations: 2019.* Natural Environment Research Council, Special Committee on Seals pp.154.

SCOS. (2022). *Scientific Advice on Matters Related to the Management of Seal Populations: 2021.* Natural Environment Research Council, Special Committee on Seals pp.266.

SCOS. (2023). *Scientific Advice on Matters Related to the Management of Seal Populations: 2022.* Natural Environment Research Council, Special Committee on Seals pp.206.

Scottish Government. (2019). *Strategic Habitat Regulations Appraisal (HRA): Screening and Appropriate Assessment Information Report – Final.* Sectoral Marine Plan for Offshore Wind Energy. The Scottish Government pp.463.

Scottish Government. (2022). *Salmon fishery statistics - 2021 season.* Scottish Government pp.4.

Scottish Government. (2023). *Scottish salmon and sea trout fishery statistics 2022.* Scottish Government pp.17.

Seagreen Wind Energy Limited. (2012). *Chapter 13: Marine mammals.* Environmental Statement Volume I. Seagreen Wind Energy pp.157pp.

Seagreen Wind Energy Limited. (2018). *Appendix 10A: Marine Mammal Baseline Technical Report. Baseline characterisation update.*

Seagreen Wind Energy Ltd. (2021). *Seagreen Alpha and Bravo Site UXO clearance – European Protected Species Risk Assessment and Marine Mammal Mitigation Plan.*

SEAMARCO. (2011). *Temporary hearing threshold shifts and recovery in a harbor porpoise and two harbor seals after exposure to continuous noise and playbacks of pile driving sounds.* The Netherlands pp.20.

SEER. (2022). *Risk to marine life from marine debris and floating offshore wind cable systems.* Report by National Renewable Energy Laboratory and Pacific Northwest National Laboratory for the U.S. Department of Energy, Wind Energy Technologies Office

Siebert, U., Stürznickel, J., Schaffeld, T., Oheim, R., Rolvien, T., Prenger-Berninghoff, E., Wohlsein, P., Lakemeyer, J., Rohner, S. and Schick, L. A. (2022). *Blast injury on harbour porpoises (Phocoena phocoena) from the Baltic Sea after explosions of deposits of World War II ammunition*. Environment international, 159, pp.107014.

Silva, S., Araújo, M. J., Bao, M., Mucientes, G. and Cobo, F. (2014). *The haematophagous feeding stage of anadromous populations of sea lamprey Petromyzon marinus: low host selectivity and wide range of habitats*. Hydrobiologia, 734 (1), pp.187-199. DOI:10.1007/s10750-014-1879-4.

Simply Blue Energy (Scotland) Limited. (2023). *Salamander Offshore Wind Farm Environmental Impact Assessment Scoping Report*. pp.545.

Sinclair, R. R., Sparling, C. E. and Harwood, J. (2020). *Review Of Demographic Parameters And Sensitivity Analysis To Inform Inputs And Outputs Of Population Consequences Of Disturbance Assessments For Marine Mammals.* Scottish Marine and Freshwater Science Vol 11 No 14. Marine Scotland Science

Smith, I. P. and Smith, G. W. (1997). *Tidal and diel timing of river entry by adult Atlantic salmon returning to the Aberdeenshire Dee, Scotland*. Journal of Fish Biology, 50 (1), pp.463–474. DOI:0022–1112/97/030463+12 $25.00/0/jb960306.

Snyder, D. B., Bailey, W. H., Palmquist, K., Cotts, B. R. T. and Olsen, K. (2019). *Evaluation of Potential EMF Effects on Fish Species of Commercial or Recreational Fishing Importance in Southern New England.* U.S. Dept. of the Interior, Bureau of Ocean Energy Management. Sterling, Virginia, USA pp.59.

Soloway, A. G. and Dahl, P. H. (2014). *Peak sound pressure and sound exposure level from underwater explosions in shallow water*. Journal of the Acoustical Society of America, 136 (3), pp.EL218. DOI:10.1121/1.4892668.

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr, C. R., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E. and Richardson, W. J. (2007). *Marine mammal noise-exposure criteria: initial scientific recommendations*. Aquatic Mammals, 33 (4), pp.414-521.

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, 45 (2), pp.125-232. DOI:10.1578/am.45.2.2019.125.

Southall, B. L., Nowacek, D. P., Bowles, A. E., Senigaglia, V., Bejder, L. and Tyack, P. L. (2021). *Marine mammal noise exposure criteria: assessing the severity of marine mammal behavioral responses to human noise*. Aquatic Mammals, 47 (5), pp.421-464.

Sparling, C. E. (2012). *Seagreen Firth of Forth Round 3 Zone Marine Mammal Surveys.* SMRUL-ROY-2012-006 to Royal Haskoning and Seagreen Wind Energy Ltd pp.32.

Sparling, C. E., Coram, A. J., McConnell, B., Thompson, D., R., H. K. and Northridge, S. P. (2013). *Wave & Tidal Consenting Position Paper Series. Marine Mammal Impacts.* Natural Environment Research Council pp.11pp.

Sparling, C. E., Speakman, J. R. and Fedak, M. A. (2006). *Seasonal variation in the metabolic rate and body composition of female grey seals: fat conservation prior to high-cost reproduction in a capital breeder?* Journal of Comparative Physiology B, 176, pp.505-512.

SSE Renewables. (2022a). *Appendix 10.4: Marine mammal iPCoD modelling report.* Berwick Bank Wind Farm Offshore Environmental Impact Assessment pp.33.

SSE Renewables. (2022b). *Chapter 9: Fish and Shellfish Ecology.* Berwick Bank Wind Farm Environmental Impact Assessment Report Volume 2. Berwick Bank Wind Farm pp.93.

SSE Renewables. (2022c). *Chapter 10: Marine Mammals.* Berwick Bank Wind Farm Environmental Impact Assessment Report Volume 2. Berwick Bank Wind Farm pp.149.

SSE Renewables. (2022d). *Marine Mammal Technical Report: Appendix 10.2.* Berwick Bank Offshore Environmental Impact Assessment. Berwick Bank Wind Farm

SSE Renewables. (2022e). *Report to Inform Appropriate Assessment Part Two: Special Areas of Conservation.* Berwick Bank Wind Farm pp.237.

Statoil. (2015). *Hywind Scotland Pilot Park: Environmental Statement (Full Report).* Document Number A-100142-S35-EIAS-001. pp.462pp.

Stelfox, M., Hudgins, J. and Sweet, M. (2016). *A review of ghost gear entanglement amongst marine mammals, reptiles and elasmobranchs*. Marine Pollution Bulletin, 111 (1), pp.6-17. DOI:https://doi.org/10.1016/j.marpolbul.2016.06.034.

Stephens, P. A., Boyd, I. L., McNamara, J. M. and Houston, A. I. (2009). *Capital breeding and income breeding: their meaning, measurement, and worth*. Ecology, 90 (8), pp.2057-67. DOI:10.1890/08-1369.1.

Stephenson, S. J. (2015). *Marine noise inputs: Technical Note on Underwater Noise.* Xodus Group Ltd. Document Number Report No. A-100142-S20-TECH-001 Rev A01.

Stevens, A. (2023). *Seal haul-out and telemetry data in relation to the Ossian Offshore Wind Farm.* Document Number SMRUC-RPS-2023-011.

Stober, U. and Thomsen, F. (2021). *How could operational underwater sound from future offshore wind turbines impact marine life?* Journal of the Acoustical Society of America, 149 (3), pp.1791. DOI:10.1121/10.0003760.

Stromar Offshore Wind Farm. (2024). *Environmental Impact Assessment: Offshore Scoping Report.* Document Number 08468168. pp.580.

Taeubert, J.-E. and Geist, J. (2017). *The relationship between the freshwater pearl mussel (Margaritifera margaritifera) and its hosts*. Biology Bulletin, 44 (1), pp.67-73.

Tasker, M., Amundin, M., Andre, M., Hawkins, A., Lang, W., Merck, T., Scholik-Schlomer, A., Teilmann, J., Thomsen, F., Werner, S. and Zakharia, M. (2010). *Marine Strategy Framework Directive - Task Group 11 Report Underwater Noise and Other Forms of Energy.* Publications Office of the European Union. Luxembourg

Teilmann, J., Larsen, F. and Desportes, G. (2007). *Time allocation and diving behaviour of harbour porpoises (Phocoena phocoena) in Danish and adjacent waters.* Journal of Cetacean Research and Management, 9, pp.201-210.

Thompson, D., Brownlow, A., Onoufriou, J. and Moss, S. (2015a). *Collision Risk and Impact Study: Field Tests of Turbine Blade-Seal Carcass Collisions.* Report to Scottish Government. Document Number Version F1. pp.1-16.

Thompson, P. M., Brookes, K. L. and Cordes, L. S. (2015b). *Integrating passive acoustic and visual data to model spatial patterns of occurrence in coastal dolphins*. ICES Journal of Marine Science, 72 (2), pp.651-660.

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*. Proceedings of the Royal Society B, 280 (1771), pp.20132001. DOI:10.1098/rspb.2013.2001.

Thompson, P. M., Graham, I. M., Cheney, B., Barton, T. R., Farcas, A. and Merchant, N. D. (2020). *Balancing risks of injury and disturbance to marine mammals when pile driving at offshore windfarms*. Ecological Solutions and Evidence, 1 (2). DOI:10.1002/2688-8319.12034.

Tougaard, J. (2021). *Thresholds for behavioural responses to noise in marine mammals. Background note to revision of guidelines from the Danish Energy Agency.* DCE – Danish Centre for Environment and Energy. Document Number 225.

Tougaard, J., Carstensen, J., Wisz, M. S., Jespersen, M., Teilmann, J. and Bech, N. I. (2006). *Harbour Porpoises on Horns Reef Effects of the Horns Reef Wind Farm.* Final Report to Vattenfall A/S. Roskilde, Denmark pp.112.

Tougaard, J., Henriksen, O. D. and Miller, L. A. (2009a). *Underwater noise from three types of offshore wind turbines: estimation of impact zones for harbor porpoises and harbor seals*. Journal of the Acoustical Society of America, 125 (6), pp.3766-73. DOI:10.1121/1.3117444.

Tougaard, J., Henriksen, O. D. and Miller, L. A. (2009b). *Underwater noise from three types of offshore wind turbines: Estimation of impact zones for harbor porpoises and harbor seals*. The Journal of the Acoustical Society of America, 125 (6), pp.3766-3773. DOI:10.1121/1.3117444.

Tougaard, J., Wright, A. J. and Madsen, P. T. (2015). *Cetacean noise criteria revisited in the light of proposed exposure limits for harbour porpoises*. Mar Pollut Bull, 90 (1-2), pp.196-208. DOI:10.1016/j.marpolbul.2014.10.051.

Tricas, T. C. and Carlson, B. A. (2012). *Electroreceptors and magnetoreceptors*. *In:* Sperlakis, N. (ed.) *Cell Physiology Source Book: Essentials of Membrane Biophysics.* 4th ed. San Diego, US: Academic Press.

Tyack, P. L., Johnson, M. P., Zimmer, W. M. X., De Soto, N. A. and Madsen, P. T. (2006). *Acoustic behavior of beaked whales, with implications for acoustic monitoring*. IEEE.

UK Government, Department for Business Energy and Industrial Strategy (BEIS), Marine Management Organisation (MMO), Joint Nature Conservation Committee (JNCC), Natural England (NE), Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), Department of Agriculture Environment and Rural Affairs (DAERA), NatureScot, Marine Scotland and Natural Resources Wales. (2022). *Marine environment: unexploded ordnance clearance joint interim position statement* [Online]. Available at: https://www.gov.uk/government/publications/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement. Accessed on: 10 May 2024.

van Beest, F. M., Teilmann, J., Hermannsen, L., Galatius, A., Mikkelsen, L., Sveegaard, S., Balle, J. D., Dietz, R. and Nabe-Nielsen, J. (2018). *Fine-scale movement responses of free-ranging harbour porpoises to capture, tagging and short-term noise pulses from a single airgun*. R Soc Open Sci, 5 (1), pp.170110. DOI:10.1098/rsos.170110.

Van Der Hoop, J. M., Corkeron, P., Kenney, J., Landry, S., Morin, D., Smith, J. and Moore, M. J. (2016). *Drag from fishing gear entangling North Atlantic right whales*. Marine Mammal Science, 32 (2), pp.619-642. DOI:10.1111/mms.12292.

von Benda-Beckmann, A. M., Aarts, G., Sertlek, H. Ö., Lucke, K., Verboom, W. C., Kastelein, R. A., Ketten, D. R., van Bemmelen, R., Lam, F.-P. A., Kirkwood, R. J. and Ainslie, M. A. (2015). *Assessing the Impact of Underwater Clearance of Unexploded Ordnance on Harbour Porpoises (Phocoena phocoena) in the Southern North Sea*. Aquatic Mammals, 41 (4), pp.503-523. DOI:10.1578/am.41.4.2015.503.

Westerberg, H. and Lagenfelt, I. (2008). *Sub-sea power cables and the migration behaviour of the European eel*. Fisheries Management and Ecology, 15 (5-6), pp.369-375. DOI:https://doi.org/10.1111/j.1365-2400.2008.00630.x.

Westerberg, H., Langenfelt, I., Andersson, I., Wahlberg, M. and Sparrevik, E. (2007). *Inverkan på fisk och fiske av SwePol Link - Fiskundersökningar 1999-2006 (in Swedish).* Swedish Fisheries Agency

Whyte, K. F., Russell, D. J. F., Sparling, C. E., Binnerts, B. and Hastie, G. D. (2020). *Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities*. The Journal of the Acoustical Society of America, 147 (6), pp.3948. DOI:10.1121/10.0001408.

Wilcox, C., Heathcote, G., Goldberg, J., Gunn, R., Peel, D. and Hardesty, B. D. (2015). *Understanding the sources and effects of abandoned, lost, and discarded fishing gear on marine turtles in northern Australia*. Conserv Biol, 29 (1), pp.198-206. DOI:10.1111/cobi.12355.

Wildlife Trusts. (2023). *Northern North Sea* [Online]. Available at: https://www.wildlifetrusts.org/marine-protected-areas/england/northern-north-sea. Accessed on: October 2023.

Wilhelmsson, D., Malm, T., Thompson, R., Tchou, J., Sarantakos, G., McCormick, N., Luitjens, S., Gullström, M., Patterson Edwards, J. K., Amir, O. and Dubi, A. (2010). *Greening Blue Energy: Identifying and Managing the Biodiversity Risks and Opportunities of Offshore Renewable Energy.* IUCN. Edited by Gland, Switzerland pp.102.

Wilson, B., Thompson, P. and Hammond, P. (1997). *Habitat use by bottlenose dolphins: seasonal distribution and stratified movement patterns in the Moray Firth, Scotland*. Journal of Applied Ecology, pp.1365-1374.

Wisniewska, D. M., Johnson, M., Teilmann, J., Rojano-Donate, 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 (11), pp.1441-6. DOI:10.1016/j.cub.2016.03.069.

Wright, A. and Cosentino, M. (2015). *JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys: We can do better*. Marine Pollution Bulletin, 100. DOI:10.1016/j.marpolbul.2015.08.045.

WSDOT. (2011). *Biological Assessment Preparation for Transport Projects - Advanced Training Manual.* Washington State Department of Transport

Wursig, B. and Gaily, G. A. (2002). *Marine mammals and aquaculture: conflicts and potential resolutions.* Responsible Marine Aquaculture CAP International Press. New York pp.45-59.

Wyles, H., Boehme, L., Russell, D. and Carter, M. (2022). *A Novel Approach to Using Seabed Geomorphology as a Predictor of Habitat Use in Highly Mobile Marine Predators: Implications for Ecology and Conservation*. Frontiers in Marine Science, 9**,** pp.1. DOI:10.3389/fmars.2022.818635.

Yano, A., Ogura, M., Sato, A., Sakaki, Y., Shimizu, Y., Baba, N. and Nagasawa, K. (1997). *Effect of modified magnetic field on the ocean migration of maturing chum salmon, Oncorhynchus keta*. Marine Biology, 129**,** pp.523-530.

ossian

SSE Renewables

Marubeni

CIP
Copenhagen Infrastructure Partners


**Ossian Offshore Wind Farm Limited**
Inveralmond House
200 Dunkeld Road
Perth
PH1 3AQ

**Project Office**
Fourth Floor
10 Bothwell Street
Glasgow
G2 6NT

ossianwindfarm.com