Green Volt Offshore Windfarm

Section 36C and Marine Licence Variation Application Report

Appendix I: Section 36C Variation EIA Screening Report

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Section 36.C Variation

EIA Screening Report

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Glossary of Acronyms

Acronym	Definition
AA	Appropriate Assessment
ADD	Acoustic Deterrent Device
AEOSI	Adverse Effect on Site Integrity
AEZ	Archaeological Exclusion Zone
CAA	Civil Aviation Authority
CEMP	Construction Environmental Management Plan
CES	Coastal East Scotland
CGNS	Celtic & Greater North Sea
CO_2	Carbon Dioxide
COLREGs	International Regulations for Preventing Collisions at Sea, 1972
CRM	Collision Risk Modelling
EDR	Effective Deterrent Range
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMF	Electromagnetic Field
ES	East Scotland
FLO	Fisheries Liaison Officer
GHG	Greenhouse Gas
GNS	Greater North Sea
GVOWL	Green Volt Offshore Windfarm Limited
HDD	Horizontal Directional Drilling
HF	High Frequency
hr	Hour
HRA	Habitats Regulations Appraisal
IAC	Inter-Array Cables
IAMMWG	Inter-Agency Marine Mammal Working Group
JNCC	Joint Nature Conservation Committee
kJ	Kilojoule
km^2	Square Kilometre
kV	Kilovolt
LAT	Lowest Astronomical Tide
LF	Low Frequency
LSE	Likely Significant Effect
Ltd.	Limited

m	Metre
m^2	Square Metre
m^3	Cubic Metre
MCA	Maritime and Coastguard Agency
MD-LOT	Marine Directorate Licensing Operations Team
MF	Moray Firth
MHWS	Mean High Water Springs
MINNS	Marine Invasive Non-Native Species
mm	Millimetre
MMMP	Marine Mammal Mitigation Protocol
MU	Management Unit
MW	Megawatt
N/E	Threshold Not Exceeded
NA	North Atlantic
NAS	Noise Abatement System
NCMPA	Nature Conservation Marine Protected Area
Nm	Nautical Mile
NMFS	National Marine Fisheries Service
NRA	Navigational Risk Assessment
NS	North Sea
NtM	Notice to Mariners
O&G	Oil and Gas
O&M	Operation and Maintenance
OEC	Offshore Export Cables
OfTI	Offshore Transmission Infrastructure
OSP	Offshore Substation Platform
PCW	Phocid carnivores in Water
PEMP	Project Environment Monitoring Programme
PMF	Priority Marine Feature
PTS	Permanent Threshold Shift
RMS	Root Mean Square
s.36	Section 36 (Electricity Act 1989)
s.36C	Section 36C (Electricity Act 1989)
SCANS	Small Cetaceans in the European Atlantic and North Sea
SCOS	Special Committee on Seals
SEL	Sound Exposure Level

SEL_{cum}	Cumulative Sound Exposure Level
SEL_{ss}	Sound Exposure Level single strike
SMWWC	Scottish Marine Wildlife Watching Code
SPA	Special Protection Area
SPL	Sound Pressure Level
SPL_{peak}	Peak Sound Pressure Level
SSB	Semi-Submersible Barge
SSP	Semi-Submersible Platform
SWL	Still Water Level
T	Tonne
TLP	Tension Leg Platform
TTS	Temporary Threshold Shift
UK	United Kingdom
UWN	Underwater Noise
UXO	Unexploded Ordnance
VHF	Very High Frequency
WCS	Worst-case Scenario
WSI	Written Scheme of Investigation
WTG	Wind Turbine Generator

Glossary of Terminology

Term	Description
Buzzard	Buzzard Platform Complex.
Green Volt Offshore Windfarm	Offshore windfarm including associated onshore and offshore infrastructure development (Combined On and Offshore Green Volt Projects).
Horizontal Directional Drilling	Mechanism for installation of export cable at landfall.
Inter-Array Cables	Cables which link the wind turbines to each other and the offshore substation platform.
Moorings	Mechanism by which wind turbine generators are fixed to the seabed.
Offshore Development Area	Encompasses i) Windfarm Site, including offshore substation platform ii) Offshore Export Cable Corridor to Landfall, iii) Export Cable Corridor to Buzzard Platform Complex.
Offshore Export Cables	The cables which would bring electricity from the offshore substation platform to the Landfall or to the Buzzard Platform Complex.
Offshore Infrastructure	All of the offshore infrastructure, including wind turbine generators, offshore substation platform and all inter-array and export cables.
Offshore Substation Platform	A fixed structure located within the Windfarm Site, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable form for export to shore.
Project	Green Volt Offshore Windfarm project as a whole, including associated onshore and offshore infrastructure development.
Windfarm Site	The area within which the wind turbine generators, offshore substation platform and inter-array cables will be present.

Executive Summary

1. The Green Volt Offshore Windfarm (the Project) is being developed by Flotation Energy Ltd. (Flotation Energy) and Vårgrønn AS (Vårgrønn). Flotation Energy and Vårgrønn have formed the dedicated company, Green Volt Offshore Windfarm Limited (GVOWL).
2. GVOWL intends to request a variation (the Proposed Variation) to the existing Section 36 (s.36) Consent (Scottish Ministers, 2024a) for the Project in accordance with Section 36C of the Electricity Act 1989 (as amended) and Part 9 of the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017. GVOWL also seeks to vary Marine Licences (Scottish Ministers, 2024b and 2024c) for the Windfarm Site (MS-00010230) and the Offshore Transmission Infrastructure for the Export Cable to landfall (MS-00010232).
3. Proposed design changes aim to optimise windfarm efficiency and enable utilisation of the best available technological solution for the site, considering results of site investigations and further development of engineering design. The Project s.36 Consent (Scottish Ministers, 2024a) red line boundary is not changing, and the Windfarm Site area remains at 116 square kilometres, as consented. Additionally, the maximum generating capacity of the windfarm will remain at 560 megawatts. The Proposed Variation aims to maximise the potential for renewable energy production to meet government targets, including the Scottish Government's targets to have an installed offshore wind capacity of 11 gigawatts, and 50 % of total energy consumption from renewable sources by 2030[*], and enables an optimal technology solution to be deployed at the site both from an environmental impact and technical feasibility perspective.
4. The key driver for the Proposed Variation is to optimise the project design by incorporating updated wind turbine generator (WTG) parameters that reflect technological advances and efficiencies available on the current market. These updates are intended to enhance the efficiency and reliability of renewable energy generation. In support of the design optimisation, minor adjustments to associated infrastructure within the Windfarm Site are also proposed to facilitate alignment with the updated WTG parameters.

[*] The Scottish Government are currently consulting on proposed updates to the Offshore Wind Policy Statement 2020, with consultation set to end on 13/08/2025. To reinforce the Scottish Government's absolute commitment to maximising the deployment of offshore wind in Scotland, the Scottish Government is seeking to reset its ambition and is now aiming to deploy up to 40 GW by 2035 – 2040 in addition to the existing operational capacity.

5. The Proposed Variation will capture the following in relation to the Windfarm Site:
    - Altered WTG parameters to reflect present-day availability of appropriate technology;
    - Amended WTG spacing to allow an optimised layout to maximise wind resource use, whilst maintaining navigational safety;
    - Altered floating substructure and mooring parameters to accommodate the WTGs under consideration; and
    - Refined maximum number of cable and pipeline crossings for inter-array cables.
6. The Proposed Variation will capture the following in relation to the transmission assets:
    - Altered Offshore Substation Platform (OSP) topside dimensions to reflect present day technology availability;
    - Updated OSP foundation parameters to accommodate changes in OSP topside dimensions; and
    - Amended pin-pile driving methodology to accommodate changes in OSP foundation parameters.
7. This document has been produced to provide the supporting information to inform the request for an Environmental Impact Assessment (EIA) Screening Opinion for the Proposed Variation.
8. Following review of the Project 2023 EIA Report (EIAR) (GVOWL, 2023a) and the additional information, submitted in support of the s.36 and Marine Licence consent applications, and further consideration of the potential environmental effects arising from the Proposed Variation, it is concluded that the Proposed Variation would not give rise to any new or materially different residual effects compared to those identified in the 2023 EIAR (GVOWL, 2023a). On this basis, the changes introduced through the Proposed Variation are not considered likely to give rise to significant effects on the environment. As such, it is determined that the Proposed Variation does not constitute EIA development, under the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017, the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2007 and the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017, and no further EIA is required.
9. A review of the conclusions of the original Habitats Regulations Appraisal (HRA) (Marine Directorate Licensing Operations Team (MD-LOT), 2024) has also been undertaken, in addition to a review of the findings of the HRA Screening Report (GVOWL, 2023b), the Report to Inform Appropriate Assessment (GVOWL, 2023c), and the Supplementary Ornithological Assessment Report (GVOWL, 2023d) submitted by GVOWL. This review considered whether the Proposed Variation could introduce any new or materially different potential for Likely Significant Effect (LSE) on European Sites, either alone or in-combination.

10. The screening process confirmed that the Proposed Variation does not introduce any new or materially different activities, parameters, or impact pathways that would alter the conclusions of the original HRA (MD-LOT, 2024) in relation to LSE. As such, the Proposed Variation does not trigger the need for further assessment under the Conservation (Natural Habitats &c.) Regulations 1994 or the Conservation of Offshore Marine Habitats and Species Regulations 2017.

1 Introduction

1.1 Background

11. In April 2024, the Marine Directorate Licensing Operations Team (MD-LOT), on behalf of Scottish Ministers, granted Green Volt Offshore Windfarm Limited (GVOWL) consent under Section 36 (s.36) of the Electricity Act 1989, Part 4 of the Marine (Scotland) Act 2010, and Part 4 of the Marine and Coastal Access Act 2009. This granted GVOWL consent to construct and operate the Green Volt Offshore Windfarm and associated offshore transmission infrastructure (OfTI) (the Project).

12. The consent applications were supported by a comprehensive Environmental Impact Assessment (EIA) Report (EIAR) (GVOWL, 2023a), submitted in 2023, alongside Additional Information provided during the determination process. This information informed the assessment of potential environmental effects associated with the Project and supported the decision-making process for both the s.36 Consent (Scottish Ministers, 2024a) and Marine Licences (Scottish Ministers, 2024b, 2024c, and 2024d).

13. The Project will enable oil & gas (O&G) platforms in the Outer Moray Firth to be electrified with renewable energy. The Project seeks to provide electrification of the Buzzard O&G platform complex (hereafter referred to as Buzzard), with discussions ongoing with various other Outer Moray Firth platforms regarding the potential to use electricity generated by the Project. The Project will also provide renewable energy to the Scottish mainland.

14. The Project will enable up to 500,000 tonnes (T) of carbon dioxide (CO_2) per year to be mitigated, including 300,000 T of CO_2 from the electrification of O&G assets in the area.

15. The Offshore Development Area is comprised of the Windfarm Site, and two Offshore Export Cable (OEC) routes. The Windfarm Site covers an area of 116 square kilometres (km^2), with a maximum export capacity of up to 560 megawatts (MW) generated by up to 35 floating wind turbine generators (WTG) harnessing average wind speeds of 10.98 m/s. The Windfarm Site will be located on the Ettrick and Blackbird decommissioned O&G brownfield site at depths of 100 to 115 metres (m) (**Figure 1.1**).

16. The Project will have two OEC routes, the first to electrify Buzzard located approximately 20 km away from the Windfarm Site, and the second to bring excess electricity to shore, reaching landfall at approximately 80 km from the Windfarm Site near Peterhead, on the Aberdeenshire coast.

17. Key Offshore Infrastructure includes:

- WTGs;
- Substructures and foundations;
- Mooring and anchoring;
- Offshore Substation Platform (OSP);
- Inter-Array Cables (IAC);

- Up to two OECs to Buzzard; and
- Up to two OECs to landfall.

LEGEND

- Windfarm Site
- Offshore Export Cable Corridor

0 20

Kilometres

Data:
Esri, HERE, Garmin, USGS
Contains OS data © Crown Copyright and database right 2025
Contains data from OS Zoomstack
Esri, HERE

PROJECT: GREEN VOLT

TITLE: Figure 1.1 Green Volt Offshore Development Area including Export Cable Corridors

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GREEN VOLT

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1.2 Intention to Vary Existing Consents

18. GVOWL is seeking a variation to the existing s.36 Consent (Scottish Ministers, 2024a) and associated Marine Licences (Windfarm Site (MS-00010230) (Scottish Ministers, 2024b) and the Offshore Transmission Infrastructure for the Export Cable to landfall (MS-00010232) (Scottish Ministers, 2024c)) to accommodate updates to key project parameters. These changes (the Proposed Variation) include updated design envelope values for WTGs and associated floating substructures and moorings, IACs, and the OSP, which reflect refined design assumptions and current market availability. The variation to the s.36 Consent (Scottish Ministers, 2024a) will be sought under Section 36C (s.36C) of the Electricity Act 1989. Variations to the Marine Licences (Scottish Ministers, 2024b and Scottish Ministers, 2024c) will be requested under Section 30(7) of the Marine (Scotland) Act 2010 and Section 72(3) of the Marine and Coastal Access Act 2009.

19. The Proposed Variation aims to optimise windfarm efficiency and enable utilisation of the best available technological solution for the site, considering results of site investigations and further development of engineering design. Given the nascent and rapidly developing nature of floating offshore wind technology and changing market availability since the Project consent application in 2023, the Proposed Variation seeks to update some WTG parameters to reflect technological advances and efficiencies available on the current market. To accommodate the WTGs under consideration, other aspects of the project design, such as floating substructures and moorings, have been further developed and refined.

20. The Proposed Variation does not seek to change the windfarm consented maximum export capacity of 560 MW, nor the spatial extent of the Windfarm Site (116 km^2) or the OfTI consented red-line boundary.

21. The Proposed Variation aims to maximise the potential for renewable energy production to meet government targets, including the Scottish Government's targets to have an installed offshore wind capacity of 11 gigawatts, and 50 % of total energy consumption from renewable sources by 2030[*], and enables an optimal technology solution to be deployed at the site both from an environmental impact and cost of technology perspective.

22. To support the application for a consent variation, GVOWL would like to request an EIA Screening Opinion for the Proposed Variation from the Scottish Ministers via MD-LOT.

23. GVOWL considers that the Proposed Variation should be screened out for the purposes of EIA in terms of the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (the Electricity Works EIA Regulations), the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2007 and the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (together, the EIA Regulations).

24. Under the EIA Regulations, development will be considered EIA development if it either:

    1. Constitutes Schedule 1 Development; or
    2. Constitutes Schedule 2 Development and is likely to have significant effects on the environment having regard to the factors set out in Schedule 3[†].

25. Schedule 2 paragraph 2 of the Electricity Works EIA Regulations states that the following will constitute EIA development:

26. *"Any change to or extension (including a change in the manner or period of operation) of development of a description listed in schedule 1 or in paragraph 1 of this schedule [Schedule 2] where that development is already authorised, executed, or in the process of being executed, and the change or extension may have significant adverse effects on the environment."*

27. The Proposed Variation is a change to an already authorised generating station and, as such, would constitute Schedule 2 development (and thus require an EIA) if the Proposed Variation were to have significant adverse effects on the environment. Development which comprises a change requires EIA only if the change or extension in itself is likely to have significant environmental effects. Similar provisions are in the Marine Works (Environmental Impact Assessment) Regulations 2007 and the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017.

28. As demonstrated in this Screening Report, the Proposed Variation does not introduce new or materially different residual effects compared to those identified in the 2023 EIAR (GVOWL, 2023a). On this basis, the changes introduced through the Proposed Variation are not considered likely to give rise to significant effects on the environment, and therefore the Proposed Variation does not constitute an EIA development. As such, it is appropriate to screen the Proposed Variation out of the requirement for an EIA.

29. In parallel, the potential for Likely Significant Effect (LSE) on any European Site has been considered in accordance with the Conservation (Natural Habitats &c.) Regulations 1994 and the Conservation of Offshore Marine Habitats and Species Regulations 2017. No new or materially different impact pathways for effects are introduced by the Proposed Variation, and so the changes introduced by the Proposed Variation do not give rise to LSE.

30. MD-LOT's guidance note: Application for Variation of section 36 consents (Scottish Government, 2019) also confirms at paragraph 31 that where a *"proposed variation is unlikely to have significant environmental effects, no EIA Report or process would be required in respect of the variation application."*

[†] Having regard to the characteristics of the works (e.g., the size and design of the works, cumulative effects with other existing works and/or approved works, the use of natural resources, in particular land, soil, water and biodiversity, etc.), the location of the works and characteristics of the potential impact (e.g. the magnitude and spatial extent of the impact, the nature of the impact, etc.).

1.3 Scope of this Document

31. This document (the Screening Report) has been produced to provide the supporting information to inform the request for a Screening Opinion from Scottish Ministers for the Proposed Variation, and contains the following:

- Details of the screening methodology (**Section 1.4**):
- Details of the Project and the Proposed Variation to the Project (**Section 2**);
- Screening to determine whether the Proposed Variation has the potential to give rise to new or materially different environmental effects compared to those identified in the 2023 EIAR (GVOWL, 2023a) (**Section 3** and **Appendix A**);
- Further evaluation of the significance of any potential changes in effect by the Proposed Variation (**Section 4**); and
- Summary of conclusions and screening outcome (**Section 5**).

32. Updated collision risk modelling (CRM) and Underwater Noise (UWN) modelling for the Proposed Variation have been undertaken by APEM Limited (Ltd.) and Seiche Ltd., respectively. The technical reports detailing these modelling exercises are provided in **Appendix B** and **Appendix C** of this Screening Report. The results of these modelling exercises have directly informed the screening evaluation presented in this Screening Report.

1.4 Methodology

33. The approach to screening has followed the requirements of the EIA Regulations, in particular Schedule 3, which sets out the criteria to determine whether a change to a development is likely to have significant effects on the environment. These criteria include the characteristics of the development, its location, and the characteristics of the potential impacts.

34. To assess whether the Proposed Variation met the threshold for requiring EIA, the below methodology was applied. **Figure 1.2** illustrates how this methodology has been applied in practice, showing the linked stages from design envelope comparison through to screening, and detailed evaluation of effect.

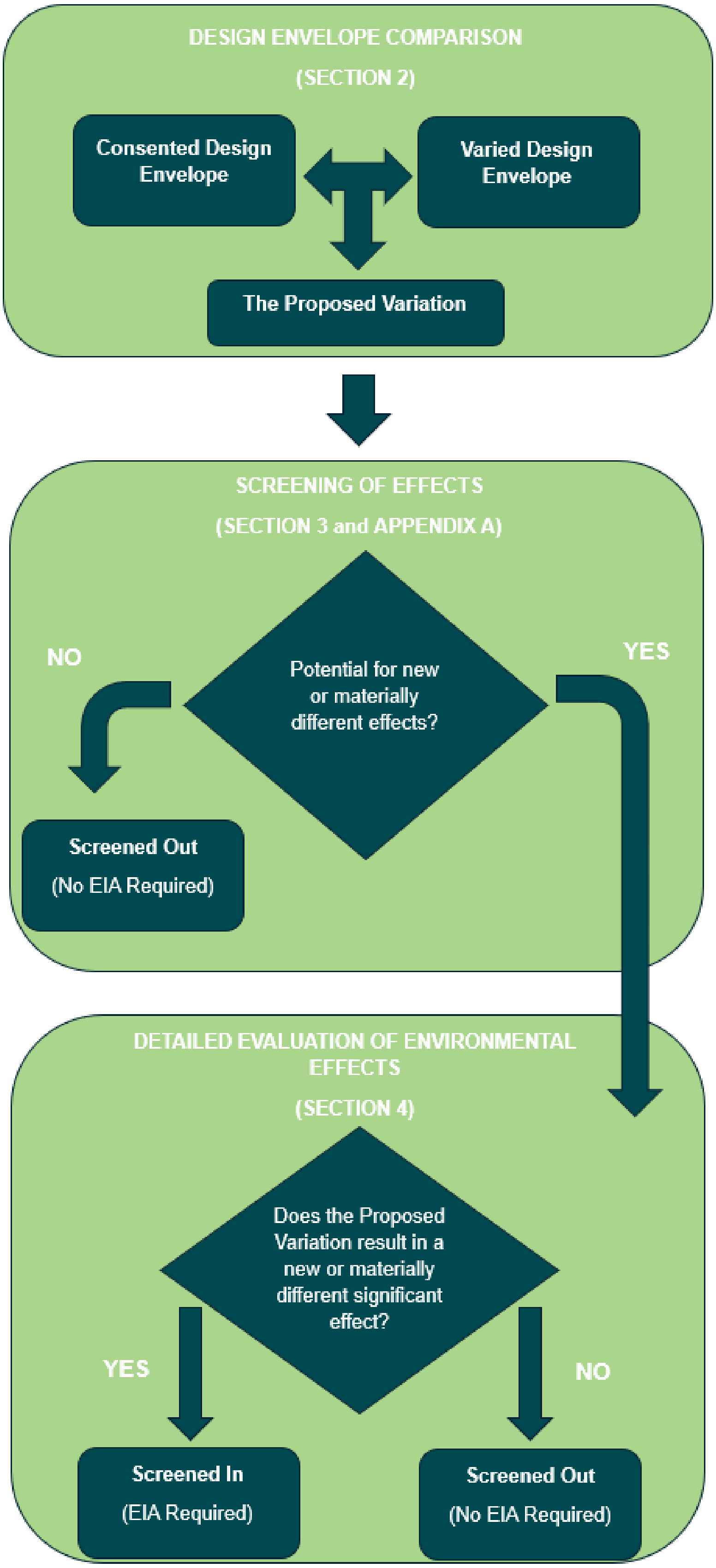

Figure 1.2 Flow chart showing the linked stages of the applied methodology

1.4.1 Design Envelope Comparison

35. Each offshore infrastructure component, relevant to the Proposed Variation, was reviewed against specific parameters included in the consented design envelope, as set out in the s.36 Consent (Scottish Ministers, 2024a), Marine Licences (Scottish Ministers, 2024b, 2024c), and the original Project Description of the EIAR (**Chapter 5: Project Description**) (GVOWL, 2023a). Design parameter tables were developed for each relevant infrastructure component (**Section 2**), these tables clearly outline:

- The originally consented design envelope;
- The proposed varied design envelope; and
- Whether the variation falls outside the consented design envelope and therefore requires formal variation through the Proposed Variation.

36. The varied design envelope presented for each infrastructure component covered by this Proposed Variation has been developed to accommodate the full range of infrastructure options under consideration. For each parameter, values have been systematically reviewed in comparison to the consented design envelope to determine whether an update or refinement is warranted. Where the varied minimum and/or maximum value of a parameter falls outside the corresponding consented value, the varied design envelope has been updated to reflect the more conservative value to ensure a precautionary assessment. In cases where only one bound of the parameter falls outside the consented range, the consented value for the other bound is retained.

37. Where varied parameter values remain within the consented design envelope, the approach to refinement is parameter specific and justified on a case-by-case basis. For certain parameters, even if the proposed varied minimum and maximum values are within the consented range, the varied design envelope has been refined to reflect updated, more accurate information or a change in design, thereby improving the precision of the evaluation. Conversely, for other parameters, the consented values are maintained without refinement to provide continuity with the originally consented baseline whilst maintaining flexibility.

38. This ensures that the varied design envelope provides a consistent and precautionary basis for evaluation across all relevant infrastructure components.

39. These design envelope comparison tables formed the basis for identifying which parameters fell outside the consented design envelope and thus required inclusion in the Proposed Variation. This, in turn, informed the EIA screening process, which considered whether changes to parameters that fall outside the consented design envelope could give rise to new or materially different significant environmental effects.

1.4.2 Screening of Effects

40. An initial screening exercise (**Section 3**) was undertaken to consider each impact pathway previously assessed in the 2023 EIAR (GVOWL, 2023a) in the context of the Proposed Variation (**Section 2**). The purpose of this step was to identify whether the varied design envelope could give rise to any new or materially different environmental effects.

41. Initial screening was informed by:

- The nature and magnitude of the proposed changes;
- The sensitivity of the receiving environment;
- The mitigation measures already secured under the existing consent, including consent conditions; and
- Professional judgement based on experience, and accounting for the conclusions of the 2023 EIAR (GVOWL, 2023a).

42. Cumulative and decommissioning effects were considered as part of the initial screening exercise. The Proposed Variation's contribution to cumulative effects was evaluated in relation to each impact pathway, further detail is provided in **Appendix A**. Decommissioning effects were addressed by analogy to the construction phase, reflecting the comparable nature, magnitude and duration of impacts, as explained further in **Appendix A**.

43. Following this process, each impact pathway was either:

- Screened out, where no change was expected, or where any increase in magnitude was negligible and did not result in a material change to the residual effect as presented in the 2023 EIAR (GVOWL, 2023a); or
- Taken forward for further evaluation (**Section 4**), where a change in magnitude could potentially result in a materially different effect.

44. To ensure a robust approach, the precautionary principle was applied throughout the screening process.

1.4.3 Detailed Evaluation of Environmental Effects

45. For each impact pathway brought forward for detailed evaluation, a comparison has been made between the associated worst-case scenario (WCS) parameters presented in the 2023 EIAR (GVOWL, 2023a) and those defined for the Proposed Variation. The WCS parameters presented in the 2023 EIAR (GVOWL, 2023a) covered both the Windfarm Site infrastructure (whilst the OSP is formally recognised as part of the OfTI, it is located within the Windfarm Site, and is therefore included under the Windfarm Site Infrastructure) and the OECs, where relevant, and the same approach has been applied to the WCS parameters presented for the Proposed Variation. It is noted that the Proposed Variation only relates to infrastructure within the Windfarm Site, therefore the WCS parameters related to the OECs remain consistent with those presented in the 2023 EIAR (GVOWL, 2023a).

46. The WCS for the consented design envelope reflected the WCS presented in the 2023 EIAR (GVOWL, 2023a) to ensure consistency with the parameters previously assessed and consented. This approach allowed for a like-for-like comparison to determine whether the changes introduced through the Proposed Variation gave rise to new or materially different significant environmental effects. While the consented WCS parameters have been retained for this comparative exercise, the WCS for the Proposed Variation incorporated refinements based on improved understanding of construction and O&M methods where relevant. These refinements were applied only where they are directly applicable to the impact pathway being assessed and supported a more informed evaluation of likely effects.

47. The WCS comparison informed the detailed evaluation that was carried out to determine whether the effect of the Proposed Variation would be materially different from that previously assessed in the 2023 EIAR (GVOWL, 2023a). This included consideration of the nature, scale, duration, and overall magnitude of the relevant impact pathways, the receiving environment, and the conclusions of the original assessment, including committed mitigation measures and residual effects.

48. Where impact pathways were taken forward for further evaluation in **Section 4**, consideration was also given to the potential for any change in the Project's contribution to cumulative effects because of the Proposed Variation (**Section 4.7**). Similarly, decommissioning effects are considered by analogy to construction phase impacts, consistent with the approach taken in the 2023 EIAR (GVOWL, 2023a) and the initial screening exercise (**Section 3** and **Appendix A**).

49. This detailed evaluation was informed by the criteria set out in Schedule 3 of the EIA Regulations, which guide consideration of:

- The characteristics of the development (e.g., scale, nature, complexity);
- The location of the development, particularly the sensitivity of the receiving environment; and
- The characteristics of the potential impact (e.g., nature, magnitude, probability, duration, and frequency).

50. This approach ensured that all the proposed changes, that fell outside the consented design envelope, and had the potential to materially alter the conclusions on the 2023 EIAR were subject to a consistent and robust level of evaluation. By applying the Schedule 3 criteria to those changes with the potential for new or materially different effects, the evaluation supported a clear and evidence-based conclusion on whether any new or materially different environmental effects should be screened in for further consideration under the EIA Regulations.

51. Habitats Regulations Appraisal (HRA) screening has also been undertaken (**Section 4.8**) in accordance with the Conservation (Natural Habitats &c.) Regulations 1994 and the Conservation of Offshore Marine Habitats and Species Regulations 2017 (the Habitats Regulations). The purpose of the screening exercise was to determine whether the Proposed Variation, either alone or in-combination, could give rise to any new or materially different LSE on European Sites, beyond that previously assessed.

52. The screening process focused solely on the Proposed Variation, and the changes it introduces, rather than re-opening the HRA of the Project as a whole. The process involved a comparative review of the activities, parameters, and impact pathways assessed in the original HRA, considering whether the changes introduced through the Proposed Variation could reasonably be expected to alter the previous conclusions of LSE.

53. Where the original HRA concluded that an Appropriate Assessment (AA) was required, this screening exercise did not re-assess the test of Adverse Effect on Site Integrity (AEOSI). Instead, it considered whether the Proposed Variation could introduce any new or materially different potential for LSE that would require a revised or additional AA.

2 Project Description and Proposed Variation

2.1 Existing Project Characteristics

2.1.1 Description of the Project

2.1.1.1 Section 36 Consent

54. The s.36 Consent (Scottish Ministers, 2024a) defines the Project as an offshore energy generating station, with a maximum generating capacity of 560 MW of electricity, comprised of the following:

- Up to 35 three-blade horizontal axis WTGs each with:
  a. A maximum rotor hub height of 143 m above Lowest Astronomical Tide (LAT);
  b. A maximum height to blade tip of 264 m above LAT;
  c. A maximum rotor diameter of 242 m;
  d. A blade tip clearance of 22 m above Mean High Water Springs;
  e. A maximum blade width of 8 m;
  f. A minimum turbine spacing of 1,540 m; and
  g. A maximum turbine spacing of 1,936 m.
- Up to 35 of either semi-submersible platform (SSP), semi-submersible barge (SSB), or tension leg platform (TLP) floating substructures for the WTGs;
- Catenary mooring lines with a radius of up to 650 m and a maximum of six drag embedment anchors per WTG, if SSP or SSB is used;
- A mooring line radius of up to 100 m and a maximum of six suction pile anchors per WTG, if TLP is used; and
- A maximum of 134 km of IAC.

55. The total area of the Windfarm Site, within which all the energy generating station infrastructure will be housed, is 116 km^2.

2.1.1.2 Marine Licences

56. Three marine licences have been granted for the Project:

- **Marine Licence for the generating station infrastructure (MS-00010230) (Scottish Ministers, 2024b):** This Marine Licence is within the scope of the Proposed Variation and covers the installation of all infrastructure related to the generation of renewable energy within the Windfarm Site. It largely reflects the parameters consented under the s.36 Consent (Scottish Ministers, 2024a). Section 2.2 of the marine licence provides a description of the licensed activity, whilst Section 2.3 provides a description of the materials to be used during the licensed activity;
- **Marine Licence for OECs to landfall (MS-00010232) (Scottish Ministers, 2024c):** This Marine Licence is also within the scope of the Proposed Variation. It covers the construction of OfTI, including the OSP, located within the Windfarm Site, and the OECs to landfall. The description of the licensed activity and the materials to be used are detailed in Sections 2.2 and 2.3 of the Marine License; and
- **Marine Licence for OECs to Buzzard (MS-00010231) (Scottish Ministers, 2024d):** This Marine Licence covers the construction of the OECs to Buzzard. No changes are proposed to the licensed activity covered by this Marine Licence, as no changes are proposed to the OECs leading to Buzzard. As such, this Marine Licences is outside the scope of the Proposed Variation. Section 2.2 and 2.3 of the Marine Licence provide detail on the licensed activity and the materials to be used.

2.2 Proposed Changes to Windfarm Parameters and Variation Requirements

57. The Proposed Variation focusses only on infrastructure within the Windfarm Site (which includes the OSP) and is primarily driven by a change in some WTG parameters to those assessed in the 2023 EIAR (GVOWL, 2023a) and consented under the existing s.36 Consent (Scottish Ministers, 2024a) and the relevant Marine Licences (Scottish Ministers, 2024b, and Scottish Ministers, 2024c). As detailed in **Section 1** since the application submission and the issuing of the s.36 Consent (Scottish Ministers, 2024a), technological developments in the floating offshore wind market have resulted in the availability of newer WTG models with different physical and operational parameters, reflecting current market availability and supplier specifications.

58. To accommodate the changes to WTG parameters and ongoing design development, some aspects of associated windfarm infrastructure, such as the floating substructures, mooring systems and the OSP have also been further developed and refined to help optimise renewable energy generation. The Proposed Variation does not seek to change the windfarm maximum export capacity of 560 MW, nor the 116 km^2 spatial extent of the Windfarm Site, nor the maximum number of 35 WTGs to be installed in the windfarm, as consented.

59. The following sections provide a summary of the proposed changes to each relevant component of the offshore Windfarm Site infrastructure.

2.2.1 Wind Turbine Generators

60. This section summarises the key WTG parameters as originally consented under the s.36 Consent (Scottish Ministers, 2024a) in addition to the scheduled changes to these parameters under the Proposed Variation.

61. GVOWL is currently considering two conventional three-blade, horizontal-axis WTG options:

- Scenario 1: Up to 35 x 14 MW WTGs (with power boost option to 15 MW); and
- Scenario 2: Up to 30 x 18.5 MW WTGs.

62. A final decision on the WTG option will be made post-consent, enabling flexibility to reflect market availability and project optimisation. For both scenarios, the Project's total installed capacity will remain limited to 560 MW in accordance with the existing s.36 Consent (Scottish Ministers, 2024a). However, under the varied design envelope, the final number of WTGs in each scenario is constrained by the scenario-specific maximum total rotor swept area, together with the capacity and dimensions of the selected WTG type:

- Scenario 1: Maximum total rotor swept area of 1.531 km^2, corresponding to 35 x 14 MW WTGs (with power boost option to 15 MW); and
- Scenario 2: Maximum total rotor swept area of 1.593 km^2, corresponding to 30 x 18.5 MW WTGs.

63. These constraints mean no more WTGs than stated above can be deployed in either scenario.

64. **Table 2.1** presents the key parameters for the consented design envelope alongside the varied design envelope. For the varied design envelope, each scenario (Scenario 1 and Scenario 2) includes a minimum and maximum value for every parameter. For each parameter, the table identifies whether:

- The parameter remains unchanged;
- The parameter has changed but remains within the consented envelope, in which case a decision is required on whether the varied parameter will be included as part of the Proposed Variation; or
- The parameter has changed and now sits outside the consented design and therefore requires formal variation, and as such forms part of the Proposed Variation.

The parameters requiring formal variation differ depending on the scenario considered, however, these are summarised collectively here and include: single WTG capacity, maximum rotor hub height, maximum rotor tip height, maximum rotor diameter, maximum chord length, maximum windfarm total rotor sept area, maximum rotor swept area per WTG, and both minimum and maximum WTG spacing.

CRM for seabirds (**Appendix B**) has been undertaken for both WTG scenarios (Scenario 1: 35 x 14 MW WTGs and Scenario 2: 30 x 18.5 MW WTGs), which together represent the full range of currently considered configurations within the varied design envelope.

In the current s.36 Consent (Scottish Ministers, 2024a) and generating station marine licence (MS-00010230) (Scottish Ministers, 2024b), the WTG rotor hub height and rotor tip height parameters are measured relative to LAT, and blade tip clearance is measured relative to Mean High Water Springs (MHWS).

For the varied design envelope presented in **Table 2.1**, these parameters are instead measured relative to Still Water Level (SWL) to provide a consistent datum reference and clarity that the distances presented for each parameter remain true at all sea levels given that the WTG substructures are floating. GVOWL intends for any varied s.36 Consent and marine licence to reference SWL for these parameters, replacing the current MHWS and LAT references.

This change in datum reference is a presentational change only and does not alter the intended clearances or heights in relation to the sea surface as designed, noting the WTGs are floating and will therefore rise and fall with the tide.

Table 2.1 Summary of the key parameters for the varied WTG design envelope in relation to the consented design envelope (Changes to design envelope are highlighted in blue)

Parameter	Consented Design Envelope		Varied Design Envelope				Comments
			Scenario 1:		Scenario 2:		
	Min	Max	Min	Max	Min	Max	
Windfarm total capacity (MW)	N/A	560	N/A	560	N/A	560	No change to consented parameter
Single WTG capacity (MW)	14	16	14 (with power boost option to 15 MW)		**18.5**		**Scenario 2 maximum outside the consented design envelope; included in the Proposed Variation**
Number of WTGs within the Windfarm Site	N/A	35	N/A	35	N/A	30	No change to consented parameter
Number of blades	3	3	3		3		No change to consented parameter
Axis	Horizontal	Horizontal	Horizontal		Horizontal		No change to consented parameter
Blade tip clearance (m)	22 (above MHWS)	22 (above MHWS)	22 **(above SWL)**		22 **(above SWL)**		No change to consented parameter; **referenced to SWL (previously MHWS)**

Parameter	Consented Design Envelope		Varied Design Envelope				Comments
			Scenario 1:		Scenario 2:		
	Min	Max	Min	Max	Min	Max	
Rotor hub height (m)	132 (above LAT)	143 (above LAT)	132 **(above SWL)**	**148 (above SWL)**	132 **(above SWL)**	**159 (above SWL)**	**Scenario 1 and Scenario 2 maximums outside the consented design envelope; included in the Proposed Variation. Referenced to SWL (previously LAT)**
Rotor tip height (m)	242 (above LAT)	264 (above LAT)	242 **(above SWL)**	**266 (above SWL)**	242 **(above SWL)**	**289 (above SWL)**	**Scenario 1 and Scenario 2 maximums outside the consented design envelope; included in the Proposed Variation. Referenced to SWL (previously LAT)**
Rotor diameter (m)	220	242	220	236	220	**260**	**Scenario 2 maximum outside the consented design envelope; included in the Proposed Variation**
Maximum chord length (m)	N/A	8	N/A	**6.5**	N/A	**6.81**	**Scenario 1 and Scenario 2 maximum chord length reduced; included in the Proposed Variation**

Parameter	Consented Design Envelope		Varied Design Envelope				Comments
			Scenario 1:		Scenario 2:		
	Min	Max	Min	Max	Min	Max	
Windfarm total rotor swept area (km^2)‡	1.330	1.610	1.330	**1.531**	1.330	**1.593**§	**Scenario 1 and Scenario 2 maximum rotor swept area reduced; included in the Proposed Variation**
Rotor swept area per WTG (km^2)**	0.038	0.046	0.038	0.044	0.038	**0.053**	**Scenario 2 maximum outside the consented design envelope; included in the Proposed Variation**
Spacing between WTGs (m)	1,540	1,936	**1,000**	**5,000**	**1,000**	**5,000**	**Scenario 1 and Scenario 2 minimum and maximum outside the consented design envelope; included in the Proposed Variation**
Colour	Matt light grey/off white, with yellow substructure	Matt light grey/off white, with yellow substructure	Matt light grey/off white, with yellow substructure		Matt light grey/off white, with yellow substructure		No change to consented parameter

‡ An error was identified in the conversion of rotor swept area from m^2 to km^2 in the 2023 EIAR (GVOWL, 2023a). As a result, the original Project Description (**Chapter 5: Project Description**) (GVOWL, 2023a) incorrectly stated the total swept area as 1,330 km^2 (minimum) to 1,610 km^2 (maximum). The correct values are 1.330 km^2 and 1.610 km^2 respectively. This error relates solely to unit conversion and does not affect the assessment of environmental impacts presented in the 2023 EIAR (GVOWL, 2023a).

§ The varied maximum windfarm total rotor swept area value is driven by the 30 x 18.5 MW turbine scenario.

** A unit conversion error was also identified in the rotor swept are per WTG presented in the 2023 EIAR (GVOWL, 2023a). The values were incorrectly stated as 38 km^2 (minimum) and 45.9 km^2 (maximum) in the original Project Description (**Chapter 5: Project Description**) (GVOWL, 2023a). The correct values are 0.038 km^2 and 0.046 km^2 respectively. This error relates solely to the conversion of m^2 to km^2 and does not affect the assessment of environmental impacts presented in the 2023 EIAR (GVOWL, 2023a).

Parameter	Consented Design Envelope		Varied Design Envelope				Comments
	Min	Max	Scenario 1:		Scenario 2:		
			Min	Max	Min	Max	
Navigation lighting	As required by Civil Aviation Authority (CAA), Maritime and Coastguard Agency (MCA), etc.	As required by CAA, MCA, etc.	As required by CAA, MCA, etc.		As required by CAA, MCA, etc.		No change to consented parameter

2.2.2 Floating Substructures and Mooring System

65. The proposed changes to the WTG design envelope (**Section 2.2.1**) have influenced the design and configuration of the floating substructures and associated mooring systems. Parameter updates have been made to accommodate the increase in the maximum WTG size and associated loading requirements, in alignment with current engineering design standards and supply chain challenges. This section outlines the key changes to the floating substructures and mooring system parameters, comparing them against the consented design envelope and identifying where updates are required under the Proposed Variation.

66. **Table 2.2** provides an overview of the key parameters for the floating substructures and mooring system in relation to the consented design envelope, for each parameter the table identifies whether:

- The parameter remains unchanged;
- The parameter has changed but remains within the consented design envelope, in which case a decision is required on whether the varied parameter will be included as part of the Proposed Variation; or
- The parameter has changed and now sits outside the consented design envelope and therefore requires formal variation, and as such forms part of the Proposed Variation.

67. The consented design envelope includes three floating substructure options: (i) SSP; (ii) SSB; and (iii) TLP. As part of the Proposed Variation, a varied design envelope has been developed for the SSP and the SSB floating substructure types and their associated mooring system to reflect ongoing design development and supply chain engagement. As set out in **Table 2.2**, some parameters now fall outside the originally consented design envelope and require variation. Key changes include:

- An increase in the maximum mooring line radius from 650 m to 1,000 m;
- An increase in the maximum number of mooring lines and anchors per WTG structure from six to nine (i.e. to allow consideration of a 3 x 3 mooring configuration per substructure); and
- Associated updated anchor specifications.

68. As a result of the above changes, the Proposed Variation would result in some increase to the seabed footprint of the Project. As detailed in **Table 2.2** the operation and maintenance (O&M) phase mooring system footprint would increase from 1,950 square metres (m^2) to 3,816 m^2 per WTG. The proposed changes to the mooring system would also have implications for the construction phase mooring system footprint. The WCS for the mooring system, presented in **Section 4.1**, **4.2**, and **4.3**, provides further detail on the construction phase seabed footprint of the varied mooring system.

69. The TLP floating substructure type, along with certain anchoring types (gravity-based anchors and torpedo anchors) remain part of the originally consented design envelope, but no changes to design envelope parameters associated with these components are sought under this Proposed Variation. As such, these technologies are excluded from the parameter table (**Table 2.2**) and they remain part of the consented design envelope.

70. Where parameters, under the Proposed Variation, sit outside of the original design envelope, the potential environmental implications are discussed in the subsequent sections of this Screening Report.

Table 2.2 Summary of the key varied design parameters for the SSP and SSB floating substructures and the associated mooring system in relation to the consented design envelope (Changes to design envelope are highlighted in blue)

Parameter	Consented Design Envelope	Varied Design Envelope	Comments
	Max	Max	
Floating Substructure (SSP and SSB)			
Maximum horizontal face length (m)	125	125	No change to consented parameter
Platform width (m)	110	110	No change to consented parameter
Operational draught (m)	13	**20**	**Outside the consented design envelope; included in the Proposed Variation**
Maximum elevation above waterline (m)	7	**20.5**	**Outside the consented design envelope; included in the Proposed Variation**
Maximum mooring points (per WTG)	6	**9**	**Outside the consented design envelope; included in the Proposed Variation**
Colour	High visibility yellow colour (RAL 1023 or similar) to satisfy the requirements of the CAA, MCA and NLB.	High visibility yellow colour (RAL 1023 or similar) to satisfy the requirements of the CAA, MCA and NLB.	No change to consented parameter
Navigational lighting	As required by CAA, MCA, etc	As required by CAA, MCA, etc	No change to consented parameter
Mooring System			
Mooring lines	Catenary/Semi-taut	**Catenary, semi-catenary, taut, semi-taut**	**Outside the consented design envelope; included in the Proposed Variation**

Parameter	Consented Design Envelope	Varied Design Envelope	Comments
	Max	Max	
Mooring line radius (m)	650	**1,000**	**Outside the consented design envelope; included in the Proposed Variation**
Anchor type	Drag embedment anchors, torpedo anchors, gravity-based anchors, or suction pile anchors	Drag embedment anchors, torpedo anchors, gravity-based anchors, or suction pile anchors	No change to consented parameter
Maximum number of anchors (per WTG)	6	**9**	**Outside the consented design envelope; included in the Proposed Variation**
Anchor weight (per anchor) (T)	10 – 35 (drag embedment)	**50 (drag embedment); 370 (suction piles)**	**Outside the consented design envelope; included in the Proposed Variation**
Maximum anchor seabed displacement (per WTG structure) (m^2)	600	**864**	**Outside the consented design envelope; included in the Proposed Variation**
Maximum operation phase seabed footprint of the moorings (per WTG structure) (m^2)	1,950	**3,816**	**Outside the consented design envelope; included in the Proposed Variation**

2.2.3 Inter-Array Cables

71. Updates to the design and configuration of the IAC system are proposed to accommodate the updated WTG and floating foundation/mooring parameters and layout considerations and project design development aligned with current engineering design standards. This section outlines the key proposed changes to the IAC system design parameters, comparing them against the consented design envelope and identifying where updates to these parameters are required under the Proposed Variation.

72. **Table 2.3** provides an overview of the key parameters for the IAC system in relation to the consented design envelope, for each parameter the table identifies whether:

   - The parameter remains unchanged;
   - The parameter has changed but remains within the consented design envelope, in which case a decision is required on whether the varied parameter will be included as part of the Proposed Variation; or
   - The parameter has changed and now sits outside the consented design envelope and therefore requires formal variation, and as such forms part of the Proposed Variation.

73. No changes to the maximum number and length of IACs are proposed. As part of the varied design envelope some parameters associated with the installation and protection of the IACs have been updated to reflect outcomes of further engineering surveys, assessments and design development. Most IAC design parameters remain within the consented design envelope; however, some parameters now fall outside and are therefore included within the Proposed Variation. These parameters include:

   - Proposed cable trench depth amended from a range of 0.6 m to 1.5m to a range of 0.6 m to 3 m (average 1.5 m): This adjustment is informed by updated engineering assessments and survey data and optimises installation flexibility;
   - Maximum cable trench width increased from 3 m to 5 m: The wider trench allows for improved installation flexibility and accommodates variations in cable routing and seabed features identified during detailed design;
   - Maximum width of seabed disturbance from jetting increased from 10 m to 15 m: This increase reflects updates jetting techniques and accounts specifically for potential mobile seabed sediments, ensuring effective trenching while managing environmental impacts;
   - Maximum number of cable and pipeline crossings increased from nine to 20: As the final WTG and IAC layouts are not yet confirmed, this increase provides flexibility to accommodate known cables and pipelines and to optimise routing during detailed design.

- Maximum number of concrete mattresses per crossing increased from 15 to 60: This change corrects a previous calculation error in the original design envelope. Further detail is provided in the accompanying footnote[6].
- Introduction of a new dynamic IAC configuration (tethered wave configuration): This design includes a tether clamp, tether, and base structure at the touchdown point to secure the cable, reducing seabed movement, improving stability, and mitigating fatigue related risks.

74. Where parameters, under the Proposed Variation, sit outside the original design envelope the potential environmental implications are discussed in the subsequent sections of this Screening Report.

[6] It is important to highlight that this increase does not reflect a change to the footprint or volume of mattressing per crossing, which remains the same. Rather this corrects a miscalculation in the original design envelope for the resultant number of mattresses of a given size required to cover the mattressing footprint, where 60 mattresses should have been reported. As such, this does not represent a change to the Project as assessed in the 2023 EIA. but instead corrects an earlier reporting error, with the parameter now accurately presented in the varied design envelope.

Table 2.3 Summary of the key varied design parameters for the IAC system in relation to the consented design envelope (Changes to design envelope are highlighted in blue)

Parameter	Consented Design Envelope	Varied Design Envelope	Comments
	Max	Max	
Inter – Array Cables			
Maximum system voltage (Kilovolts (kV))	66	66	No change to consented parameter
Number of IACs	42	42	No change to consented parameter
Dynamic IAC configuration	Free hanging, and lazy wave	**Free hanging, lazy wave, and tethered wave.**	**New IAC configuration under consideration; included in the Proposed Variation**
Tether clamp area (per clamp) (m^2)	N/A	**49**	**New parameter; included in the Proposed Variation**
Total length of IACs (km^2)	134	134	No change to consented parameter
Cable outer diameter (millimetres (mm))	220	220	No change to consented parameter
Installation technique	Surface laid on seabed with rock berm or trenched (trenching, jetting, ploughing, and mechanical cutting) to proposed trench depth	Surface laid on seabed with rock berm or trenched (trenching, jetting, ploughing, and mechanical cutting) to proposed trench depth	No change to consented parameter

Parameter	Consented Design Envelope	Varied Design Envelope	Comments
	Max	Max	
Burial	Extent of burial to be confirmed	Extent of burial to be confirmed	No change to consented parameter
Proposed trench depth Range (m)	0.6 – 1.5	**0.6 – 3.0 (average 1.5)**	**Outside the consented design envelope; included in the Proposed Variation**
Proposed trench width (m)	3	**5**	**Outside the consented design envelope; included in the Proposed Variation**
Maximum width of disturbance from jetting (m)	10	**15**	**Outside the consented design envelope; included in the Proposed Variation**
Maximum width of disturbance from ploughing/trenching (m)	10	10	No change to consented parameter
Proposed rock berm height (m)	1.5	1.5	No change to consented parameter
Proposed rock berm width (m)	10	10	No change to consented parameter
Volume of rock protection for unburied IACs per km (cubic metres (m^3))	8,250	8,250	No change to consented parameter

Parameter	Consented Design Envelope	Varied Design Envelope	Comments
	Max	Max	
Cable and Pipeline Crossings			
Number of cable/pipeline crossings	9 (3 (cables) and 6 (pipelines))	**20**	**Outside the consented design envelope; included in the Proposed Variation**
Crossing technique	Rock berm/concrete mattressing	Rock berm/concrete mattressing	No change to consented parameter
Number of concrete mattresses per crossing	15	60	Correction to parameter presented at EIA, but no change to project design[6*]
Length of crossings (m)	300	300	No change to consented parameter
Height of crossing (m)	1.5	1.5	No change to consented parameter[‡‡]
Width of crossing (m)	7	7	No change to consented parameter
Total area of rock berm protection per crossing (m^2)	2,100	2,100	No change to consented parameter
Total volume of rock berm per crossing	3,150	3,150	No change to consented parameter

[‡‡] This parameter was incorrectly presented as 1 m in the 2023 EIAR (GVOWL, 2023a), rather than 1.5 m. All calculations of volume (e.g. Total Volume of Rock Berm per Crossing = 3,150 m^3) were based on a 1.5 m crossing height (300 m x 7 m x 1.5 m = 3,150 m^3) and so this error had no influence on the impact assessments in the 2023 EIAR (GVOWL, 2023a).

2.2.4 Offshore Substation Platform

75. As consented and described in **Chapter 5: Project Description** of the 2023 EIAR (GVOWL, 2023a), one OSP will be installed within the Windfarm Site to receive the power generated by the WTGs. At the OSP, the generated power will be transformed to a higher Alternating Current voltage for export via cables to Buzzard and to landfall for onward connection to the onshore grid connection. The OSP consists of a decked topside to contain the equipment and facilities required to transform the power to export voltage and will be supported on a four-legged jacket foundation. The OSP jacket foundation shall be secured to the seabed by either pile driving or suction piles.

76. Updates to the design and configuration of the OSP are proposed to reflect an evolved understanding of the optimisation requirements for the integration of the windfarm generation with the transmission infrastructure. These design changes are aligned to reflect technological advancements, design standards, and lessons learnt from similar developments.

77. This section outlines the key changes to the OSP related parameters, comparing them against the consented design envelope and identifying where updates to the design envelope are required under the Proposed Variation. **Table 2.4** and **Table 2.5** provide an overview of the key parameters for the OSP and the OSP foundation in relation to the consented design envelope, for each parameter the table identifies whether:

    - The parameter remains unchanged;
    - The parameter has changed but remains within the consented design envelope, in which case a decision is required on whether the varied parameter will be included as part of the Proposed Variation; or
    - The parameter has changed and now sits outside the consented design envelope and therefore requires formal variation, and as such forms part of the Proposed Variation.

78. The maximum dimensions of the OSP topside structure have increased, with the maximum length increased from 43 m to 80 m, and the width increased from 33.5 m to 55 m. The maximum topside height however remains consistent with the consented design envelope at 70 m.

79. As noted above, the OSP jacket foundation shall be secured to the seabed by either pile driving or suction piles. Some changes have been made to the design parameters for the foundation **pile driving** design option, as detailed in **Table 2.5,** to accommodate the proposed amendments to the OSP topside dimensions, as noted below:

- Maximum pile diameter has marginally increased from 3 m to 3.1 m;
- Maximum number of piles for the jacket foundation has increased from 4 to 16;
- Maximum area of scour protection per jacket foundation has increased from 1,781 m^2 to 7,124 m^2;
- Maximum volume of scour protection per jacket foundation has increased from 2,672 cubic metres (m^3) to 10,668 m^3; and
- Maximum pile penetration depth has increased from 50 m to 75 m.

80. Some amendments to the piling schedule for the pile driving installation of the OSP foundation are also proposed, including the maximum hammer driving energy, as set out in **Section 2.2.4.1.**

81. The suction pile installation design option remains unchanged from the consented design envelope as set out in **Chapter 5: Project Description** of the 2023 EIAR (GVOWL, 2023a) and is therefore excluded from the parameter comparison set out in **Table 2.5** Despite remaining unchanged, the design parameters for the suction pile installation design have still been considered in the development of the updated WCS tables set out in **Section 4**.

82. Where parameters, under the Proposed Variation, sit outside of the original design envelope the potential environmental implications are discussed in the subsequent sections of this Screening Report.

Table 2.4 Summary of the key varied design parameters for the OSP in relation to the consented design envelope (Changes to design envelope are highlighted in blue)

Parameter	Consented Design Envelope	Varied Design Envelope	Comments
	Max	Max	
Number of OSPs	1	1	No change to consented parameter
Structure type	4-legged jacket	4-legged jacket	No change to consented parameter
Height of OSP (above LAT) (m)	70	70	No change to consented parameter
Weight (T)	2,600 (jacket); 3,074 (topside)	**5,500 (jacket); 5,500 (topside); 4,000 (piles)**	**Outside the consented design envelope; included in the Proposed Variation**
Maximum topside length (m)	43	**80**	**Outside the consented design envelope; included in the Proposed Variation**
Maximum topside width (m)	33.5	**55**	**Outside the consented design envelope; included in the Proposed Variation**

Table 2.5 Summary of the key varied design parameters for the OSP foundation in relation to the consented design envelope (Changes to design envelope are highlighted in blue)

Parameter	Consented Design Envelope	Varied Design Envelope	Comments
	Max	Max	
OSP footprint area per pile[§§] (m²)	452	452	No change to consented parameter
Number of piles per foundation	4	**16**	**Outside the consented design envelope; included in the Proposed Variation**
Pile diameter (m)	3	**3.1**	**Outside the consented design envelope; included in the Proposed Variation**
Seabed penetration depth (m)	50	**75**	**Outside the consented design envelope; included in the Proposed Variation**
Pile footprint (m²)	7.1	7.1	No change to consented parameter
Scour protection material	Rock (gravel and cobble)	Rock	No change to consented parameter
Scour protection area per foundation (excluding area of piles) (m²)	1,781	**7,124**	**Outside the consented design envelope; included in the Proposed Variation**

[§§] The parameter OSP footprint area per foundation pile (m²) includes both the physical footprint of the pile itself and the associated scour protection surrounding the pile. The value of 452 m² represents the combined area these features occupy on the seabed, the realistic scenario.

Parameter	**Consented Design Envelope**	**Varied Design Envelope**	**Comments**
	Max	**Max**	
Scour protection volume per foundation (excluding area of piles) (m^3)	2,672	**10,668**	**Outside the consented design envelope; included in the Proposed Variation**
Scour protection depth (m)	1.5	1.5	No change to consented parameter
Scour protection diameter (m)	24	24	No change to consented parameter

2.2.4.1 Pile Driving Schedule for Installation of OSP Jacket Foundation

83. To accommodate the proposed amendments to the OSP and its foundation design envelope (**Section 2.2.4**) and taking into consideration information arising from current post-consent engineering surveys and assessments, the piling schedule (regime) associated with the pile driving installation option for the OSP foundation has been amended (as set out in **Table 2.6**). This revised piling schedule has been used to inform an updated UWN modelling study which has been conducted for the Proposed Variation. Further details of the assumptions and methodologies applied in the updated UWN modelling are set out in **Appendix C** of this Screening Report**.**

84. **Table 2.6** provides an overview of the key piling schedule parameters for the installation of the OSP foundation in relation to the consented design envelope[***], for each parameter the table identifies whether:

- The parameter remains unchanged;
- The parameter has changed but remains within the consented design envelope, in which case a decision is required on whether the varied parameter will be included as part of the Proposed Variation; or
- The parameter has changed and now sits outside the consented design envelope and therefore requires formal variation, and as such forms part of the Proposed Variation.

85. The key proposed changes to the piling schedule for the installation of the OSP jacket foundation include:

- Increase in maximum hammer driving energy from 2,300 kilojoule (kJ) to 3,500 kJ; and
- Decrease in the maximum number of blows per pile from 10,406 to 8,406.

86. It is noted that other key inputs to the updated UWN modelling set out in **Appendix C** include the proposed amendments to the maximum pile diameter (from 3.0 m to 3.1 m) and maximum pile penetration depth (from 50 m to 75 m), as described in **Section 2.2.4**.

[***] Consented pin-piling installation regime (schedule) is set out in **Section 5.9.1.4** of **Chapter 5: Project Description** of the 2023 EIAR (GVOWL, 2023a).

Table 2.6 Summary of amended OSP foundation installation piling schedule in relation to the consented design envelope (Changes to design envelope are highlighted in blue)

Parameter	Consented Design Envelope	Varied Design Envelope	Comments
	Max	Max	
Maximum hammer driving energy (kJ)	2,300	**3,500**	**Outside the consented design envelope; included in the Proposed Variation**
Soft start assumed starting hammer energy (kJ)	300 – 500	300 – 500	No change to consented parameter
Soft start assumed duration (hours (hr))	0.33	0.33	No change to consented parameter
Soft start assumed blows per minute	6	6	No change to consented parameter
Blows per minute	40 – 45	**40**	**Both parameters within consented design envelope; original maximums no longer proposed. Varied value used in updated WCS and updated UWN modelling.**
Maximum number of blows per pile	10,406	**8,406**	
Maximum pile time for one pile (assuming issues such as low blow rate, refusal, etc.,) (hr)	10	10	No change to consented parameter
Number of piles installed in same 24-hour period	4	4	No change to consented parameter

2.3 Project Methodologies

2.3.1 Construction and Installation Methodologies

87. The construction, installation and commissioning methodologies remain consistent with those described in **Chapter 5: Project Description** (Section 5.9: Construction) of the 2023 EIAR (GVOWL, 2023a). No material changes are proposed to the methods of installing the WTGs, the floating substructures, the moorings, the IACs, or the OSP as part of the Proposed Variation.

88. For clarity, it is noted that pre-lay activities for the moorings and IACs within the Windfarm Site may commence up to 28 months prior to WTG installation. This represents a clarification to the temporal scope of construction rather than a material change to the nature of the activities assessed in the 2023 EIAR (GVOWL, 2023a). As a result, moorings and IACs may remain on the seabed for up to 28 months before final hook-up and commissioning of the windfarm infrastructure. The implications of this clarification are considered in the relevant environment topic evaluations presented in **Section 3** (**Appendix A**) and **Section 4**. This activity (along with other construction and installation methods) will also be presented and detailed in the relevant post-consent plans, such as the Construction Method Statement and Inter-Array Cable Plans, to be submitted to Scottish Minsters for agreement at least 6 months prior to offshore commencement of the development.

2.3.2 Operation and Maintenance Methodologies

89. The O&M methodologies remain consistent with those described in **Chapter 5: Project Description** (Section 5.10: Operation and Maintenance) of the 2023 EIAR (GVOWL, 2023a). No material changes are proposed to the O&M methods covering, base of operations, safety zones, weather and sea conditions monitoring, maintenance activities, pollution prevention and waste management, and major accidents and disasters.

2.4 Proposed Variation

90. The proposed changes to the Project, which together make up the Proposed Variation are set out in the design parameter tables presented in **Section 2.2**, where the proposed changes to the WTGs, floating substructures and moorings, IACs, and the OSP are detailed. The Proposed Variation will also clarify that the definition of application documents which must be complied with in terms of the s.36 Consent (Scottish Ministers, 2024a) and Marine Licences (Scottish Ministers, 2024b, 2024c) should include this Screening Report, if accepted. This is to ensure that the proposed changes to design parameters (which are not otherwise on the face of the consents) must be complied with.

3 Screening for Potential Changes to Effects

91. A review of the existing s.36 Consent (Scottish Ministers, 2024a) and Marine Licences (Scottish Ministers, 2024b, 2024c, and 2024d), alongside the impact pathways assessed in the 2023 EIAR (GVOWL, 2023a), has been undertaken to identify whether the Proposed Variation could give rise to any new or materially different impact pathways and subsequent residual significant effects. This screening focused on whether the Proposed Variation may alter the nature, scale, duration, or magnitude of the previously assessed impacts, or introduce new pathways not previously considered.

92. An initial screening evaluation was undertaken and is presented in full in **Appendix A**, where all environmental topics and their associated impact pathways are reviewed. This evaluation screened out environmental topics and their impact pathways where it was determined that the Proposed Variation would not be likely to result in new or materially different residual effects. Where there was uncertainty, the precautionary principle was applied, and the impact pathway was brought forward for detailed evaluation, in **Section 4**, to determine whether it would result in a material change to the residual effect as presented in the 2023 EIAR (GVOWL, 2023a).

93. The following receptors have been screened in for further detailed evaluation within this Screening Report (**Section 4**):

- Marine Geology & Physical Processes;
- Benthic Ecology;
- Fish & Shellfish Ecology;
- Marine Mammal Ecology; and
- Offshore & Intertidal Ornithology.

4 Evaluation of the potential for the Proposed Variation to Change Effects

94. This section provides a detailed evaluation of receptor groups and impact pathways where the initial screening process (**Section 3** and **Appendix A**) identified the potential for new or materially different environmental effects arising from the Proposed Variation. Here a detailed evaluation determines whether the identified impact pathways should be screened in or out of the requirement for EIA, under the EIA Regulations.

4.1 Marine Geology and Physical Processes

95. Following the initial screening process presented in **Section 3** and **Appendix A**, the impact pathways listed in **Table 4.1** have been brought forward for detailed evaluation. For each impact pathway, the table presents a comparison of the WCS parameters defined in **Chapter 7: Marine Geology, Oceanography, and Physical Processes** of the 2023 EIAR (GVOWL, 2023a) with those relevant to the Proposed Variation. As outlined in **Section 1.4.3**, the WCS parameters reflect both the Windfarm Site infrastructure and the OECs, where relevant, which is consistent with the approach adopted in the 2023 EIAR (GVOWL, 2023a). As the Proposed Variation relates only to infrastructure within the Windfarm Site and no changes are proposed to the OECs, the WCS parameters for the OECs remain unchanged. No new impact pathways for this topic have been identified because of the Proposed Variation.

96. In line with **Chapter 7: Marine Geology, Oceanography and Physical Processes** of the EIAR (GVOWL, 2023a), the WCS for the impact pathway C3: Disturbance of seabed sediments during cable installation includes disturbance from installation of the OSP foundation and floating substructure mooring system, alongside cable installation activities. While these components are not cable specific, their inclusion under this impact pathway reflects the grouping used in the original assessment and is retained here for consistency. This approach avoids reframing the scope of the original impact pathway and provides a like for like comparison when determining whether the Proposed Variation materially alters the residual effect.

Table 4.1 Summary of the screened in marine geology and physical processes impact pathways and associated worst-case scenarios

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
C3: Disturbance of seabed sediments during cable installation	**Project:** **Area of seabed disturbed = 5.27††† km²** **Windfarm Site:** **Area of seabed disturbed = 1.43 km²** • Total substructure moorings: 0.06825 km² (based on worst case for catenary system); • Total area of disturbance from ploughing/jetting IACs: 1.34 km²; • Total area of rock protection for crossings of inter-array cables: 0.0189 km²; and • Total area of disturbance for OSP foundations: 0.00724 km² (based on worst case for suction bucket foundation including scour protection).	**Project:** **Area of seabed disturbed = 7.15 km²** **Windfarm Site:** **Area of seabed disturbed = 3.31 km²** • Total installation mooring system footprint, including pre-lay of moorings: 1.07856 km²; • IACs, total disturbance from jetting: 2.01 km²; • IACs, total area of rock protection for crossings: 0.042 km²; • IAC, touchdown protection 0.0672 km²; • IAC, tether clamps: 0.003773 km²; • IACs, total area of surface protection for non-buried cables: 0.1053 km²; and • OSP Foundation, total area of disturbance: 0.00724 km².	**Area of seabed disturbed:** The increase from 5.27 km² to 7.15 km² is driven solely by the change within the Windfarm Site (1.43 km² to 3.31 km²). The OECs footprint remains unchanged at 3.83 km². Despite this increase, the disturbed area remains spatially constrained, representing less than 3 % of the total Windfarm Site. **Volume of sediment disturbed:** The increase from 0.0066 km³ to 0.0076 km³ is driven solely by the change within the Windfarm Site (0.0020 km³ to 0.0030 km³). The OEC volume remains unchanged at 0.0045 km³. Despite the increase, the volume of sediment disturbed remains very small in absolute terms and is spatially constrained.

††† The total Project area for seabed disturbance was presented as 4.55 km² in the 2023 EIAR (GVOWL, 2023a). However, this summed value represented a miscalculation of the presented component parameters. When summing the component parameters listed in the 2023 EIAR (GVOWL, 2023a) the correct total is 5.27 km², therefore this corrected value in presented here.

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
	OECs: **Area of seabed disturbed = 3.83 km^2** • Total area of disturbance from ploughing/jetting of OECs: 3.00 km^2; • Total area of rock protection for non-buried OECs: 0.800 km^2; and • Total area of rock protection for OEC crossings: 0.0330 km^2. **Project:** **Volume of sediment disturbed = 0.0066 km^3** **Windfarm Site:** **Volume of sediment disturbed = 0.0020 km^3** • Total length of IAC cable: 134 km; • Average depth of burial: 1.5 m; • Maximum width of seabed disturbance from jetting/ploughing: 10 m; and • Total volume of sediment disturbed: 2,010,000 m^3. **OECs:** **Volume of sediment disturbed = 0.0045 km^3** • Total length of cable: 300 km; • Maximum depth of burial: 1.5 m;	**OECs:** **Area of seabed disturbed = 3.83 km^2** • Total area of disturbance from ploughing/jetting of OECs: 3.00 km^2; • Total area of rock protection for non-buried OECs: 0.800 km^2; and • Total area of rock protection for OEC crossings: 0.0330 km^2. **Project:** **Volume of sediment disturbed = 0.0076 km^3** **Windfarm Site:** **Volume of sediment disturbed = 0.0030 km^3** • Total length of IAC cable: 134 km; • Average depth of burial: 1.5 m (range of 0.6 m to 3 m); • Maximum width of seabed disturbance from jetting: 15 m; and • Total volume of sediment disturbed: 3,015,000 m^3. **OECs:** **Volume of sediment disturbed = 0.0045 km^3** • Total length of cable: 300 km; • Maximum depth of burial: 1.5 m;	

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
	• Maximum width of seabed disturbance from jetting/ploughing: 10 m; • Max pre-sweep volume: 35,000 m^3; and • Total maximum volume of sediment disturbed: 4,535,000 m^3.	• Maximum width of seabed disturbance from jetting/ploughing: 10 m; • Max pre-sweep volume: 35,000 m^3; and • Total maximum volume of sediment disturbed: 4,535,000 m^3.	
O3: Disturbance of seabed sediments due to catenary action of mooring lines in Windfarm Site	**Windfarm Site:** **Maximum seabed displacement for mooring system = 0.074 km^2** • Maximum seabed displacement per WTG mooring system [‡‡‡] = 2,100 m^2; and • Up to 35 WTGs.	**Windfarm Site:** **Maximum seabed displacement for mooring system = 0.134 km^2** • Maximum seabed displacement per WTG mooring system: 3,816 m^2; and • Up to 35 WTGs.	**Total mooring system seabed footprint:** The updated seabed footprint of the mooring system, of 0.134 km^2 represents 0.12 % of the Windfarm Site area (116 km^2). The increase in seabed footprint between the consented and varied design envelope is relatively small in absolute terms at 0.06 km^2. Even with the increase in footprint, the area of impact remains small and spatially limited in relation to the overall Windfarm Site.

[‡‡‡] The WCS of the 2023 EIAR (GVOWL, 2023a) presents 1,134 m^2 as the maximum seabed displacement per WTG mooring system. However, in the subsequent impact assessment, paragraph 128 of the **Chapter 7: Marine Geology, Oceanography, and Physical Processes** of the 2023 EIAR (GVOWL, 2023a), a value of 2,100 m^2 is presented as the fullest/maximum swept area. As such, this larger number is presented here to reflect the consented WCS.

4.1.1 C3: Disturbance of Seabed Sediments During Cable Installation

4.1.1.1 Existing Assessment of Effects of the Consented Project

97. Disturbance of seabed sediments during cable installation was assessed in **Chapter 7: Marine Geology, Oceanography and Physical Processes** of the EIAR (GVOWL, 2023a) as a temporary and spatially constrained effect, with short-lived increases in suspended sediment concentrations that would remain within natural variability. The magnitude of the impact was considered negligible, and the significance of the effect was assessed as negligible. No mitigation was required, and the residual effect was also deemed to be negligible and not significant in regard to the EIA Regulations.

4.1.1.2 Effects of the Proposed Variation

98. Under the varied design envelope, the total area of seabed disturbance across the Project increases from 5.27 km^2 to 7.15 km^2, driven entirely by changes within the Windfarm Site (which increases from 1.43 km^2 to 3.31 km^2), while the footprint of the OECs remain unchanged at 3.83 km^3. Similarly, the volume of sediment disturbed increases from 0.0066 km^3 to 0.0076 km^3, reflecting an increase in the Windfarm Site from 0.0020 km^3 to 0.0030 km^3.

99. The Windfarm Site lies in water depths of 100 to 115 m and is located at a substantial distance from the nearest designated site for benthic features or other protected/sensitive seabed features. Although the total disturbed area and volume of sediment are numerically greater under the Proposed Variation, they remain small in absolute terms, with the area of disturbance within the Windfarm Site representing only 2.85 % of the total area (116 km^2), under the Proposed Variation. The nature, duration, and spatial extent of the impact remain comparable to those previously assessed. While the magnitude of the impact is marginally increased, the effect is not considered materially different from that previously assessed.

4.1.1.3 Conclusion and EIA Screening Outcome

100. In accordance with the Schedule 3 criteria of the EIA Regulations, the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall scale. The location of the development is unchanged, and the receiving environment remains of negligible sensitivity in relation to the impact pathway being considered. While there is an increase in the extent of seabed disturbance under the varied design envelope, the characteristics of the potential impact, including its overall magnitude, remain comparable to that previously assessed. As the effect is not materially different from that originally assessed, and no potential for significant environmental effect has been identified, this impact pathway is screened out of further EIA.

4.1.2 O3: Disturbance of Seabed Sediments due to Catenary Action of Mooring Lines in Windfarm Site

4.1.2.1 Existing Assessment of Effects of the Consented Project

101. The catenary action of the mooring lines may cause small-scale and localised disturbance of seabed sediments around the WTGs, primarily during large storm events. The affected area per WTG is small, and sediment disturbance is limited to surface layers, mostly involving sand or muddy sand which settles out of suspension quickly. Although disturbance could occur repeatedly during the O&M phase, the overall magnitude was determined to be negligible, with the effect also assessed as negligible. No additional mitigation was required, and the residual effect was deemed to be negligible and not significant under the EIA Regulations.

4.1.2.2 Effects of the Proposed Variation

102. Under the varied design envelope, the maximum seabed displacement for the mooring system increases from 0.074 km^2 to 0.134 km^2, an increase of 0.06 km^2. Despite this increase, the impact remains very localised around the mooring lines, and therefore spatially constrained, with the total area of disturbance representing 0.12 % of the Windfarm Site area (116 km^2).

103. The worst-case disturbance is likely to occur mainly during large storm events and only affect surface sediments, which will quickly resettle nearby. The nature, extent, and frequency of the impact remain comparable to those assessed in the 2023 EIAR (GVOWL, 2023a). Although the magnitude of the impact is slightly greater under the Proposed Variation, it remains negligible overall, and the effect is not considered materially different from that previously assessed.

4.1.2.3 Conclusion and EIA Screening Outcome

104. In accordance with the Schedule 3 criteria of the EIA Regulations, the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall scale. The location of the development is unchanged, and the receiving environment remains of negligible sensitivity in relation to the impact pathway being considered. While there is an increase in the maximum seabed displacement of the mooring system under the varied design envelope, the characteristics of the potential impact, including its overall magnitude, remain comparable to that previously assessed. As the effect is not materially different from that originally assessed, and no potential for significant environmental effect has been identified, this impact pathway is screened out of further EIA.

4.2 Benthic Ecology

105. Following the initial screening process presented in **Section 3** and **Appendix A**, the impact pathways listed in **Table 4.2** have been brought forward for detailed evaluation. For each impact pathway, the table presents a comparison of the WCS parameters defined in **Chapter 9: Benthic Ecology** of 2023 EIAR (GVOWL, 2023a) with those relevant to the Proposed Variation. As outlined in **Section 1.4.3**, the WCS parameters reflect both the Windfarm Site infrastructure and the OECs, where relevant, which is consistent with the approach adopted in the 2023 EIAR (GVOWL, 2023a). As the Proposed Variation relates only to infrastructure within the Windfarm Site and no changes are proposed to the OECs, the WCS parameters for the OECs remain unchanged. No new impact pathways for this topic have been identified because of the Proposed Variation.

106. In line with **Chapter 9: Benthic Ecology of 2023 EIAR (GVOWL, 2023a)** of the EIAR (GVOWL, 2023a), the worst-case scenario for the impact pathway C1: Physical disturbance and temporary habitat loss of seabed habitat, includes disturbance from installation of the OSP foundation and floating substructure mooring system, alongside cable installation activities. While these components are not cable specific, their inclusion under this impact pathway reflects the grouping used in the original assessment and is retained here for consistency. This approach avoids reframing the scope of the original impact pathway and ensures a like for like comparison when determining whether the Proposed Variation materially alters the residual effect.

Table 4.2 Summary of the screened in benthic ecology impact pathways and associated worst-case scenarios

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
C1: Physical disturbance and temporary habitat loss of seabed habitat	**Project:** **Area of seabed disturbed = 5.27 km^2** **Windfarm Site:** Area of seabed disturbed = 1.43 km^2 **OECs:** Area of seabed disturbed = 3.83 km^2 **Project:** **Volume of sediment disturbed = 0.0066 km^3** **Windfarm Site:** Volume of sediment disturbed = 0.0020 km^3 **OECs:** Volume of sediment disturbed = 0.0045 km^3 (See **Table 4.1** for full detail on WCS for this impact pathway)	**Project:** **Area of seabed disturbed = 7.15 km^2** **Windfarm Site:** Area of seabed disturbed = 3.31 km^2 **OECs:** Area of seabed disturbed = 3.83 km^2 **Project:** **Volume of sediment disturbed = 0.0076 km^3** **Windfarm Site:** Volume of sediment disturbed = 0.0030 km^3 **OECs:** Volume of sediment disturbed = 0.0045 km^3 (See **Table 4.1** for full detail on WCS for this impact pathway)	**Area of seabed disturbed:** The increase from 5.27 km^2 to 7.15 km^2 is driven solely by the change within the Windfarm Site (1.43 km^2 to 3.31 km^2). The footprint for the OECs remains unchanged at 3.83 km^2. Despite this increase, the disturbed area remains spatially constrained, representing less than 3 % of the total Windfarm Site. **Volume of sediment disturbed:** The increase from 0.0066 km^3 to 0.0076 km^3 is driven solely by the change within the Windfarm Site (0.0020 km^3 to 0.0030 km^3). The volume for the OECs remains unchanged at 0.0045 km^3. Despite the increase, the volume of sediment disturbed remains very small in absolute terms and is spatially constrained.

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
O1: Permanent habitat loss and introduction of hard substrate	**Windfarm Site:** Area of introduction of hard substrate = 0.113 km^2 • Rock protection for non-buried cables: 0.08 km^2; and • Rock protection for cable and pipeline crossings: 0.033 km^2.	**Windfarm Site:** Area of introduction of hard substrate = 0.218 km^2 • Rock protection for non-buried cables: 0.1053 km^2; • Rock protection for cable and pipeline crossings: 0.042 km^2; • IAC touchdown protection: 0.0672 km^2; and • IAC tether clamps: 0.0038 km^2.	**Area of introduction of hard substrate:** Despite the increase from 0.113 km^2 to 0.218 km^2, the area of disturbance remains very small in absolute terms and is spatially constrained in the footprint of seabed interacting infrastructure. In total the area disturbed represents 0.19 % of the total Windfarm Site area (116 km^2).

4.2.1 C1: Physical Disturbance and Temporary Habitat Loss of Seabed Habitat

4.2.1.1 Existing Assessment of Effects of the Consented Project

107. **Chapter 9: Benthic Ecology** of the 2023 EIAR (GVOWL, 2023a) assessed physical disturbance and temporary habitat loss from construction activities across the entire Offshore Development Area, including the Windfarm Site and the OEC Corridor.

108. Within the Offshore Development Area, key benthic habitats include the seapens and burrowing megafauna in circalittoral fine mud biotope, a Priority Marine Feature (PMF), predominantly found in the Windfarm Site, and aggregations of ross worm (*Sabellaria spinulosa*) found along the OEC Corridor. The ross worm aggregations were not determined to form biogenic reef habitats but are still a species of conservation interest.

109. Physical disturbance and temporary habitat loss from construction activities, including installation of moorings, IACs, the OSP foundation, and external cable protection, were assessed as short-term, localised, and recoverable over time. The seapens and burrowing megafauna in circalittoral fine mud biotope was assessed as having medium sensitivity due to moderate resistance but low resilience to disturbance. The ross worm biotope also had medium sensitivity.

110. Overall, the magnitude of impact was assessed as low, resulting in minor adverse residual effects that are not significant in EIA terms.

4.2.1.2 Effects of the Proposed Variation

111. The Proposed Variation applies exclusively to the Windfarm Site, therefore the OEC Corridor is not relevant to this evaluation and is excluded from consideration. The main benthic receptor within the Windfarm Site is the seapens and burrowing megafauna in circalittoral fine mud biotope (a PMF).

112. The overall area of physical disturbance and temporary habitat loss across the Offshore Development Area is predicted to increase from 5.27 km^2 under the consented Project to 7.15 km^2 following the Proposed Variation. This change is driven exclusively by an increase in the disturbance footprint within the Windfarm Site, which is predicted to increase from 1.43 km^2 to 3.31 km^2.

113. Despite this increase, the nature of the impact remains consistent with the original assessment. Impacts are anticipated to be short-term, localised, and reversible. No new or materially different residual effects are predicted compared to those identified in the 2023 EIAR (GVOWL, 2023a).

4.2.1.3 Conclusion and EIA Screening Outcome

114. In accordance with the Schedule 3 criteria of the EIA Regulations, the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall scale. The location of the development is unchanged, and the receiving environment remains of the same in relation to the impact pathway being considered. While there is an increase in the extent of seabed disturbance under the varied design envelope, the characteristics of the potential impact, including its overall magnitude, remain comparable to that previously assessed. As the effect is not materially different from that originally assessed, and no potential for significant environmental effect has been identified, this impact pathway is screened out of further EIA.

4.2.2 O1: Permanent Habitat Loss and Introduction of Hard Substrate

4.2.2.1 Existing Assessment of Effects of the Consented Project

115. At the Windfarm Site the screened in benthic biotopes for this operational impact consisted mainly of the seapens and burrowing megafauna in circalittoral fine mud biotope. The biotope was assessed in **Chapter 9: Benthic Ecology** of the 2023 EIAR (GVOWL, 2023a) as of medium sensitivity.

116. After construction is complete and the Project enters the operation and maintenance phase the effect of the permanent habitat loss and introduction of hard substrate was deemed to have minor significance. No additional mitigation was required, and the residual effect was also deemed to be minor adverse - not significant, indicating that despite the noticeable changes from the baseline conditions, the underlying character, composition and attributes of the benthic environment will remain largely unaffected by the construction works. This means the existing assessment of this effect of the Project for this impact is considered not significant.

117. The presence of the WTG anchors and the OSP foundation and the associated scour protection and cable protection measures will alter the benthic substrate, from soft circalittoral fine sand/mud to hard substrate. This will lead to a permanent loss of soft substrate habitat and will impact the benthic communities reliant upon this habitat. The change in habitat type is long term and irreversible during the lifespan of the Project but the magnitude is negligible in relation to the surrounding habitat available and the highly localised nature of the impact.

4.2.2.2 Effects of the Proposed Variation

118. The area of hard substrate introduced under the Proposed Variation is predicted to increase from 0.113 km^2 to 0.218 km^2. While this represents a near doubling in absolute terms, the increase remains small relative to the total area of the Windfarm Site (116 km^2).

119. The spatial extent of the impact is limited to the immediate seabed footprint of infrastructure installation, and the main benthic receptor affected is the seapens and burrowing megafauna in circalittoral fine mud biotope, which is consistent with the original assessment.

120. Given the limited absolute area and spatial extent of habitat loss, the nature of the habitat involved, and the scale of the Windfarm Site, the increase in permanent hard substrate footprint is not anticipated to result in any new or materially different residual effects compared to those reported in the 2023 EIAR (GVOWL, 2023a).

4.2.2.3 Conclusion and EIA Screening Outcome

121. In accordance with the Schedule 3 criteria of the EIA Regulations, the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall scale. The location of the development is unchanged, and the receiving environment remains of the same nature in relation to the impact pathway being considered. While there is an increase in the extent of the introduced hard habitat under the varied design envelope, the characteristics of the potential impact, including its overall magnitude, remain comparable to that previously assessed. As the effect is not materially different from that originally assessed, and no potential for significant environmental effect has been identified, this impact pathway is screened out of further EIA.

4.3 Fish and Shellfish Ecology

122. Following the initial screening process presented in **Section 3** and Appendix A, the impact pathways listed in **Table 4.3** have been brought forward for detailed evaluation. For each impact pathway, the table presents a comparison of the WCS parameters defined in **Chapter 10: Fish and Shellfish Ecology** of the 2023 EIAR (GVOWL, 2023a) with those relevant to the Proposed Variation. As outlined in **Section 1.4.3**, the WCS parameters reflect both the Windfarm Site infrastructure and the OECs, where relevant, which is consistent with the approach adopted in the 2023 EIAR (GVOWL, 2023a). As the Proposed Variation relates only to infrastructure within the Windfarm Site and no changes are proposed for the OECs, the WCS parameters for the OECs remain unchanged. No new impact pathways for this topic have been identified because of the Proposed Variation.

Table 4.3 Summary of the screened in fish and shellfish ecology impact pathways and associated worst-case scenarios

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
C1: Physical disturbance and temporary habitat loss	**Project:** **Area of seabed disturbed = 5.27 km^2** **Windfarm Site:** Area of seabed disturbed = 1.43 km^2 **OECs:** Area of seabed disturbed = 3.83 km^2 (See **Table 4.1** for full detail on WCS for this impact pathway)	**Project:** **Area of seabed disturbed = 7.15 km^2** **Windfarm Site:** Area of seabed disturbed = 3.31 km^2 **OECs:** Area of seabed disturbed = 3.83 km^2 (See **Table 4.1** for full detail on WCS for this impact pathway)	**Area of seabed disturbed:** The increase from 5.27 km^2 to 7.15 km^2 is driven solely by the change within the Windfarm Site (1.43 km^2 to 3.31 km^2). The OECs footprint remains unchanged at 3.83 km^2. Despite this increase, the disturbed area remains spatially constrained, representing less than 3 % of the total Windfarm Site.

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
C4: Underwater noise and vibration	**Impact pile driving of OSP foundation:** • 1 minute initiation, with 6 strikes at a hammer energy of 300 kJ; • 20-minute soft start, with 800 strikes at a hammer energy of 500 kJ; • 40-minute ramp up, with 1,600 strikes and hammer energy increasing from 500 to 1,200 kJ; • 80-minute ramp up, with 3,200 strikes and hammer energy increasing from 1,200 to 2,000 kJ; and • 120-minute full power piling with 4,800 strikes and hammer energy increasing from 2,000 to 2,300 kJ.	**Impact pile driving of OSP foundation:** • 1 minute initiation, with 6 strikes at a hammer energy of 300 kJ; • 20-minute soft start, with 800 strikes at a hammer energy of 500 kJ; • 30-minute ramp up, with 1,200 strikes and hammer energy increasing from 500 to 1,500 kJ; • 40-minute ramp up, with 1,600 strikes and hammer energy increasing from 1,500 to 2,500 kJ; and • 120-minute full power piling with 4,800 strikes and hammer energy increasing from 2,500 to 3,500 kJ.	**Impact Piling of OSP foundation:** Whilst maximum hammer energy has increased from 2,300 kJ to 3,500 kJ the estimated time required to pile one pile has reduced from 4 hrs 20 mins to 3 hrs 30 mins.

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
O1: Temporary and permanent habitat loss	**Project:** **Area of seabed disturbed = 5.27 km^2** **Windfarm Site:** Area of seabed disturbed = 1.43 km^2 **OECs:** Area of seabed disturbed = 3.83 km^2 **Project:** **Volume of sediment disturbed = 0.0066 km^3** **Windfarm Site:** Volume of sediment disturbed = 0.0020 km^3 **OECs:** Volume of sediment disturbed = 0.0045 km^3 (See **Table 4.1** for full detail on WCS for this impact pathway)	**Project:** **Area of seabed disturbed = 7.15 km^2** **Windfarm Site:** Area of seabed disturbed = 3.31 km^2 **OECs:** Area of seabed disturbed = 3.83 km^2 **Project:** **Volume of sediment disturbed = 0.0076 km^3** **Windfarm Site:** Volume of sediment disturbed = 0.0030 km^3 **OECs:** Volume of sediment disturbed = 0.0045 km^3 (See **Table 4.1** for full detail on WCS for this impact pathway)	**Area of seabed disturbed:** The increase from 5.27 km^2 to 7.15 km^2 is driven solely by the change within the Windfarm Site (1.43 km^2 to 3.31 km^2). The OEC footprint remains unchanged at 3.83 km^2. Despite this increase, the disturbed area remains spatially constrained, representing less than 3 % of the total Windfarm Site. **Volume of sediment disturbed:** The increase from 0.0066 km^3 to 0.0076 km^3 is driven solely by the change within the Windfarm Site (0.0020 km^3 to 0.0030 km^3). The OEC volume remains unchanged at 0.0045 km^3. Despite the increase, the volume of sediment disturbed remains very small in absolute terms and is spatially constrained.

4.3.1 C1: Physical Disturbance and Temporary Habitat Loss of Seabed Habitat

4.3.1.1 Existing Assessment of Effects of the Consented Project

123. **Chapter 10: Fish and Shellfish Ecology** of the 2023 EIAR (GVOWL, 2023a) assessed physical disturbance and temporary habitat loss from construction activities within the Offshore Development Area (consisting of the Windfarm Site and OEC corridors).

124. Spawning and nursery grounds for sensitive species such as sandeel Ammodytes spp., herring *Clupea harengus*, and Nephrops *Nephrops norvegicus* overlapped with parts of the Offshore Development Area. However, the disturbed area was small relative to the extent of these habitats in the wider region of the North Sea, and construction activities were determined to be short-term and reversible. Designated sites for fish and shellfish were located greater than 30 km from the Offshore Development Area. Mobile species groups were considered capable of avoiding and recolonising disturbed areas. Sessile species, such as molluscs, were more sensitive, but impacts were localised, and recovery was expected over time once construction activities are completed.

125. Overall, the magnitude of impact was assessed as negligible to negligible/minor, and the residual effect was assessed as negligible adverse to minor adverse and therefore not significant.

4.3.1.2 Effects of the Proposed Variation

126. Under the Proposed Variation, the worst-case scenario for physical disturbance and temporary habitat loss during construction has increased across the Offshore Development Area from 5.27 km^2 to 7.15 km^2. This increase is solely driven by an enlarged disturbance footprint within the Windfarm Site, which has increased from 1.43 km^2 to 3.31 km^2. This equates to an increase from 0.89% to 2.85% of the Windfarm Site area (total area 116km^2). This increased Windfarm Site footprint reflects updated infrastructure design, layout and installation methodologies, including revised estimates for anchor and mooring footprints and associated seabed disturbance.

127. While this change represents a quantitative increase relative to the Project, as consented, the nature of the impact remains unchanged. The disturbance is still temporary and spatially constrained, occurring during defined construction windows and affecting small areas of seabed in the immediate vicinity of installation works, which represents a small portion of the wider seabed area.

128. Due to the unchanged nature of the impact, the increased seabed footprint continues to represent a very small portion of the extensive spawning and nursery grounds present across the Windfarm Site and wider North Sea environment. Species such as sandeel, Nephrops, herring and other demersal and pelagic species were previously assessed as having high sensitivity to seabed disturbance. However, these species make use of common habitats and are therefore not reliant on specific areas affected by the increased disturbance footprint. Consequently, they are unlikely to be significantly constrained by the Proposed Variation.

129. In the original assessment, mobile species groups were expected to avoid and/or return to affected areas once constructions activities were completed, recovery of benthic habitats was also expected to occur over varying time frames. The temporary and reversible nature of the impact, the continued availability of suitable habitat elsewhere and the lack of interaction with designated sites all remain unchanged.

130. As such, it is determined that the Proposed Variation does not materially change the magnitude of the impact or the residual effect.

4.3.1.3 Conclusion and EIA Screening Outcome

131. In accordance with the Schedule 3 criteria of the EIA regulations the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall nature and scale. The location of the development is unchanged, and the receiving environment, while used by a range of fish and shellfish species, is not considered to be of elevated or unique sensitivity in relation to this impact pathway. The characteristics of the impact pathway, including its temporally and spatially constrained nature, remain comparable to those previously assessed.

132. There is no material change to the magnitude of the impact or the residual effect of this impact pathway as a result of the Proposed Variation. This impact pathway is therefore screened out of further EIA.

4.3.2 C4: Underwater Noise and Vibration

4.3.2.1 Existing Assessment of Effects of the Consented Project

133. **Chapter 10: Fish and Shellfish Ecology** of the 2023 EIAR (GVOWL, 2023) assessed UWN and vibration from construction activities impact piling, vessel noise, survey operations, and potential unexploded ordnance (UXO) clearance. Impact piling was identified as the primary noise source, with the potential to cause mortality, physical injury, auditory injury, and/or behavioural disturbance. Modelling predicted that peak sound pressure levels (SPL_{peak}) capable of causing mortality or physical injury could occur within 147 m of the piling location, depending on species group and exposure conditions. These effects were limited to the immediate vicinity of pile-driving activity and would occur over short durations. Zones of temporary threshold shift (TTS) were predicted to extend up to approximately 4.5 km from the piling location, with behavioural disturbance effects occurring over boarder area but with diminishing intensity.

134. Mitigation measures embedded in the design include soft start piling procedures to reduce peak exposure, and low order clearance techniques where UXO disposal is required. Vessel noise and other sources such as survey and trenching equipment were assessed as producing low level broadband noise, which is unlikely to result in injury or sustained disturbance beyond a highly localised area.

135. Receptor groups ranged from low to medium sensitivity. The magnitude of impact across all groups was assessed as negligible, based on the short duration, limited spatial extent, and the avoidance and recovery capacity of mobile species. Designated sites for fish and shellfish are located over 30 km from the Offshore Development Area and were not predicted to be affected.

136. The residual effects were assessed as negligible adverse or no effect, and therefore not significant in EIA terms.

4.3.2.2 Effects of the Proposed Variation

137. The Proposed Variation includes updated UWN modelling for impact piling at the OSP location, reflecting changes to some piling parameters (**Section 2.2.4**). The maximum hammer energy is increasing from 2,300 kJ to 3,500 kJ, the maximum pile diameter is marginally increasing from 3.0 to 3.1 m, and the maximum number of pin piles for the OSP jacket foundation is increasing from four to 16 (four piles per leg).

138. The updated UWN modelling (**Appendix C**) predicts increased impact ranges for both cumulative sound exposure level (SEL_{cum}) and peak sound pressure level (SPL_{peak}), in relation to the thresholds set out by Popper *et al.* (2014). In relation to SEL_{cum} metrics due to piling of a single pin-pile, potential impact ranges for mortality of static eggs and larvae extend up to 830 m. For adult fish in the most sensitive hearing groups 3 and 4 (as defined by Popper *et al.*, 2014), mortality, recoverable injury, and TTS impact ranges extend up to 94 m, 883 m, and 12,588 m, respectively. In relation to SPL_{peak}, impact ranges for a single strike at maximum hammer energy (3,500 kJ) for mortality and recoverable injury extend up to 1,000 m for both.

139. These increases reflect a combination of factors; developments in the UWN modelling approach since the modelling was undertaken for the 2023 EAIR (GVOWL, 2023a), and changes to project specific piling schedule inputs such as the increased maximum hammer energy. (for further detail of the updated modelling approach, see **Appendix C**).

140. Despite the increase in predicted ranges in absolute terms, the nature, intensity, and duration of piling activities remain limited and constrained spatially and temporally. The impact ranges remain of comparable magnitude in the context of the spatial extent of the fish populations under consideration. The Project is a floating offshore windfarm, with piling required for only the installation of a single OSP foundation. Piling will be limited to a maximum of 16 pin piles, with each expected to take approximately 3.5 hours to install.

141. As in the consented project, soft start piling procedures will be implemented, with a gradual ramp-up in hammer energy. This embedded mitigation is expected to allow mobile fish species with sound sensitivity to leave the area before exposure to injurious sound levels.

142. UXO clearance, if needed, remains unchanged and will be managed under a separate marine licence, with appropriate mitigation measures. Other UWN sources, such as vessel activity, survey operations, and cable installation, remain consistent with the consented project and were previously assessed as resulting in localised, low level broadband noise, unlikely to cause injury or significant behavioural disturbance.

143. Given the limited spatial and temporal extent of the piling activity, the application of standard mitigation, and the fact that designated sites for fish and shellfish receptors are over 30 km from the Offshore Development Area, no new or materially different effects are predicted as a result of the Proposed Variation.

4.3.2.3 Conclusion and EIA Screening Outcome

144. In accordance with Schedule 3 of the EIA Regulations, the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a). The varied design envelope continues to represent a floating offshore windfarm of the same overall nature and scale. The receiving environment, while used by a range of fish and shellfish species, is not considered to be of elevated or unique sensitivity.

145. While updated noise modelling predicted increased impact ranges, piling activity remains spatially and temporally limited, and the impact pathway does not materially change from that assessed in the 2023 EIAR (GVOWL, 2023a).

146. No material change to the magnitude of impact or the residual effect is anticipated because of the Proposed Variation. Therefore, no new or materially different significant environmental effects are predicted, and this impact pathway is screened out of further EIA.

4.3.3 O1: Temporary and Permanent Habitat Loss

4.3.3.1 Existing Assessment of Effects of the Consented Project

147. The original assessment, as set out in **Chapter 10: Fish and Shellfish Ecology** of the 2023 EIAR (GVOWL, 2023), concluded that habitat loss during the O&M phase, resulting from the presence of subsea infrastructure, would be highly localised and limited in extent. The affected area represents a very small proportion of available habitat within the Offshore Development Area, and an even smaller proportion of habitat within the wider North Sea.

148. Spawning grounds for key species, of high sensitivity, such as herring and sandeel were determined to not be affected. The spawning grounds of other lower sensitivity species are widespread and not uniquely concentrated within the Offshore Development Area. Furthermore, whilst nursery grounds of a range of species overlap with the Offshore Development Area, due to the negligible spatial extent of loss, overlap with these functional spawning and nursery habitats represent a negligible loss at a regional scale.

149. For shellfish species, including crustaceans and molluscs, impacts were also considered to be highly localised, with mobile species expected to relocate to nearby suitable habitat. Although some sedentary species may be directly affected, the overall scale of the impact was considered too limited to affect population levels.

150. The magnitude of the impact ranged from no impact, negligible/minor, to minor, depending on the specific receptor group, with the residual effect ranging from no effect, negligible adverse, to minor adverse.

4.3.3.2 Effects of the Proposed Variation

151. Under the Proposed Variation, the worst-case scenario for temporary and permanent habitat loss during the O&M phase has increased across the Offshore Development Area from 5.27 km^2 to 7.15 km^2. This increase is solely driven by an enlarged footprint within the Windfarm Site, which has increased from 1.43 km^2 to 3.31 km^2.

152. Whilst this represents an absolute increase of the area relative to the consented project, the total area affected remains very small in absolute terms and represents 2.85 % of the Windfarm Site, and an even smaller proportion of similar habitat within the wider North Sea.

153. The spatial extent of the impact remains highly localised, limited to the immediate footprint of subsea infrastructure. There is no material change in the nature or intensity of the impact. Fish and shellfish functional habitats, such as spawning and nursery grounds, remain widespread across the region. The small increase in the area affected by habitat loss does not meaningfully reduce the available habitat at a scale relevant to population level processes. Given the limited spatial extent of the increase and the continued absence of any meaningful ecological constraint within the affected area, the Proposed Variation does not materially alter the magnitude of the impact, or the residual effect identified in the original assessment.

4.3.3.3 Conclusion and EIA Screening Outcome

154. In accordance with the Schedule 3 criteria of the EIA regulations the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall nature and scale. The location of the development is unchanged, and the receiving environment, while used by a range of fish and shellfish species, is not considered to be of elevated or unique sensitivity in relation to this impact pathway. The characteristics of the impact pathway, including its spatially constrained nature, remain comparable to those previously assessed.

155. There is no material change to the magnitude of the impact or the residual effect of this impact pathway as a result of the Proposed Variation. This impact pathway is therefore screened out of further EIA.

4.4 Marine Mammal Ecology

156. Following the initial screening process presented in **Section 3** and **Appendix A**, the impact pathways listed in **Table 4.4** have been brought forward for detailed evaluation. For each impact pathway, the table presents a comparison of the WCS parameters defined in **Chapter 11: Marine Mammal Ecology** of the 2023 EIAR (GVOWL, 2023a) with those relevant to the Proposed Variation. As outlined in **Section 1.4.3**, the WCS parameters reflect both the Windfarm Site infrastructure and the OECs, where relevant, which is consistent with the approach adopted in the 2023 EIAR (GVOWL, 2023a). As the Proposed Variation relates only to infrastructure within the Windfarm Site and no changes are proposed to the OECs, the WCS parameters for the OECs remain unchanged. No new impact pathways for this topic have been identified because of the Proposed Variation.

Table 4.4 Summary of the screened in marine mammal ecology impact pathways and associated worst-case scenarios

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
C3: Auditory injury and disturbance resulting from underwater noise during piling, including Acoustic Deterrent Device (ADD) activation	**Key foundation parameters:** • Max pile diameter: 3 m; • Max pile penetration depth: 50 m; • Indicative pile penetration depth: 40 m; and • Maximum number of piles: 4 **Key piling parameters:** • Max hammer driving energy of 2,300 kJ; • Max piling time per pile (assuming issues such as low blow rate, refusal, etc): 10 hr; • Average 'active piling time' per pile: 4.4 hr; • Total 'active piling time' for Project (based on averages): 17.6 hr (or 40 hrs for max piling time); • One pile per day; and • Undertaken over an approximate one-month period.	**Key foundation parameters:** • Max pile diameter: 3.1 m; • Final pile penetration depth: 75 m: and • Maximum number of piles 16. **Key piling parameters:** • Max hammer driving energy of 3,500 kJ; • Max piling time per pile (assuming issues such as low blow rate, refusal, etc): 10 hr; • Average 'active piling time' per pile: 3.5 hr; • Total 'active piling time' for Project (based on averages): 56 hr (or 160 hrs for max piling time); • 1 to 4 piles per day; and • Undertaken over an approximate one-month period.	<u>**Key Foundation Parameters:**</u> There is a negligible increase in pile diameter from 3 m to 3.1 m, an increase in the maximum number of piles required from four to 16, and an increase in pile penetration depth from 50 m to 75 m. These changes have influenced the key piling parameters as described below. <u>**Key Piling Parameters:**</u> The maximum hammer driving energy has increased from 2,300 kJ to 3,500 kJ, at the same time the average piling time per pile has decreased from 4.4 hrs to 3.5 hrs. However, because of the maximum number of piles required, total piling time has increased from 17.6 hrs to 56 hrs (assuming 16 piles are required for the Proposed Variation).

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
	Strike rates / number of blows: • Max blows per minutes: 40; • Min blows per minute: 1; • Average blows per minute: 40; and • Max number of blows per pile: 10,406. **Soft-start parameters:** • Soft start assumed duration of 20 minutes; • Soft start assumed 6 blows per minute (initiation), 40 blows per minute (soft start); and • Soft start starting hammer energy of ≤300 to ≤500 kJ.	**Strike rates / number of blows:** • Max blows per minutes: 40; • Average blows per minute: 40; and • Max number of blows per pile: 8,406. **Soft-start parameters:** • Soft start assumed duration of 20 minutes; • Soft start assumed 6 blows per minute (initiation), 40 blows per minute (soft start); and • Soft start starting hammer energy of ≤300 to ≤500 kJ.	**Strike Rates / Number of Blows:** Initiation and soft start parameters remain unchanged between the consented and varied worst-case scenario.
C7: Barrier effects as a result of underwater noise	The worst-case scenario for this impact pathway is represented by the worst-case scenario for impact pathway C3.	The worst-case scenario for this impact pathway is represented by the worst-case scenario for impact pathway C3.	See above.
O5: Potential entanglement with mooring lines	**Total Project mooring length across full water column profile = 137 km** • Maximum of 210 mooring lines (six per WTG structure);	**Total Project mooring length across full water column profile = 315 km** • Maximum of 315 mooring lines (nine per WTG structure);	**Total Project Mooring Length Across the Full Water Column Profile:** There is an increase to the maximum number of mooring lines per WTG structure from six to nine, as well as an increase in maximum

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
	• Mooring lines made up of anchor chain, mooring cables or polyester mooring line; • Mooring lines have a maximum radius of 650 m (catenary system); and • Maximum of 70 dynamic IACs (2 per WTG).	• Mooring lines made up of anchor chain, mooring cables or polyester mooring line; • Mooring lines have a maximum radius of 1,000 m; and • Maximum of 70 dynamic IACs (2 per WTG).	mooring line radius from 650 m to 1,000 m. These two parameters drive a 130 % increase in the total project mooring length across the entire water column.

157. The marine mammal species considered for detailed evaluation reflect those scoped in for assessment in the 2023 EIAR (GVOWL, 2023a). However, since the EIAR (GVOWL, 2023a) some of the density estimates have been updated with the Small Cetaceans in the European Atlantic and North Sea (SCANS)-IV survey in summer 2022 (Giles *et al*., 2023; as presented in **Table 4.5**). In addition, fin whale (*Balaenoptera physalus*) was recorded in survey block NS-D (Giles *et al*., 2023), which is where the Project is located and therefore has been included in the detailed evaluation.

158. **Table 4.5** presents the marine mammal density and reference populations used for the detailed evaluation for the Proposed Variation in addition to those used in the impact assessments reported in the 2023 EIAR (GVOWL, 2023a).

159. **Table 4.5** demonstrates that there have been updates to marine mammal density estimates within the Windfarm Site. Therefore, the most up to date density estimates have been applied in this detailed evaluation. In the 2023 EIAR (GVOWL, 2023a), the reference populations were based on the full or wider Management Units (MU) for harbour porpoise, dolphin species and minke whale. To ensure consistency and to enable a like-for-like comparison of effects between the Proposed Variation and the 2023 EIAR (consented Project), the same reference populations have been used in the detailed evaluation of the Proposed Variation.

160. It is acknowledged that current good practice in Scottish waters increasingly involves the use of the United Kingdom (UK) portion of each MU as a more precautionary reference population. To reflect this, both the full MU population (as used in the 2023 EIAR (GVOWL, 2023a)) and the UK portion of the MU populations have been included in **Table 4.5** and the associated evaluation tables. However, only the full MU populations have been applied in the detailed evaluation to ensure consistency with the original approach used in the 2023 EIAR (GVOWL, 2023a) and enable a valid like-for-like comparison. The UK portion populations and associated effect estimates are presented for reference purposes only and have not been used to inform the conclusions regarding whether the Proposed Variation introduces any new or materially different effects to those identified in the 2023 EIAR (GVOWL, 2023a).

Table 4.5 Summary of marine mammal density estimates and reference populations used in the detailed evaluation for the Proposed Variation (densities and reference population used in the GV EIAR (2023a) are displayed in blue for comparison)

Species	Density Estimate	Source	Reference Population	Source
Harbour porpoise (*Phocoena phocoena*)	0.76/km^2 (0.76/km^2)	HiDef aerial survey annual survey density estimate (EIAR Appendix 12.1 (GVOWL, 2023a))	346,601 North Sea (NS) MU (159,632 UK portion evaluated for information only) (346,601 NS MU)	Inter-Agency Marine Mammal Working Group (IAMMWG) (2023)
Bottlenose dolphin (*Tursiops truncatus*)	0.0298/km^2 (0.0298/km^2)	SCANS-III survey Survey Block R (Hammond *et al.*, 2021)	226 Coastal East Scotland (CES) MU (224 CES MU)	Cheney *et al.* (2024) IAMMWG (2023)
			2,022 Greater North Sea (GNS) MU (1,885 UK portion evaluated for information only) (2,022 GNS MU)	IAMMWG (2023)
White-beaked dolphin (*Lagenorhynchus albirostris*)	0.0799/km^2 (0.243/km^2)	SCANS-IV survey block NS-D (Giles *et al.*, 2023) SCANS-III survey block R (Hammond *et al.*, 2021)	43,951 Celtic & Greater North Sea (CGNS) MU (34,025 UK portion evaluated for information only) (43,951 CGNS MU)	IAMMWG (2023)

Species	Density Estimate	Source	Reference Population	Source
Atlantic white-sided dolphin (*Lagenorhynchus actus*)	0.0146/km^2 (0.028/km^2)	SCANS-IV survey block NS-E (Giles *et al.*, 2023) Windfarm Site (Waggitt *et al.*, 2019)	18,128 CGNS MU (12,293 UK portion evaluated for information only) (18,128 CGNS MU)	IAMMWG (2023)
Risso's dolphin (*Grampus griseus*)	0.0702/km^2 (0.0018/km^2)	SCANS-IV survey block NS-D (Giles *et al.*, 2023) Windfarm Site in summer (Waggitt *et al.*, 2019)	12,262 CGNS MU (8,687 UK portion evaluated for information only) (12,262 CGNS MU)	IAMMWG (2023)
Minke whale (*Balaenoptera acutorostrata*)	0.0419/km^2 (0.0387/km^2)	SCANS-IV survey block NS-D (Giles *et al.*, 2023) SCANS-III survey block R (Hammond *et al.*, 2021)	20,118 CGNS MU (10,288 UK portion evaluated for information only) (20,118 CGNS MU)	IAMMWG (2023)
Humpback whale (*Megaptera novaeangliae*)	0.000015/km^2 (0. 000015/km^2)	North Atlantic (Hammond *et al.*, 2021; Hague *et al.*, 2020)	35,000 North Atlantic (NA) MU	North Atlantic Marine Mammal Commission (2022); Hague *et al.* (2020)

Species	Density Estimate	Source	Reference Population	Source
Fin whale (*Balaenoptera physalus*)	0.0009/km² Not assessed	SCANS-IV survey block NS-D (Giles *et al.*, 2023)	3,330 NA MU	Joint Nature Conservation Committee (JNCC) (2019)
Grey seal (*Halichoerus grypus*)	0.2/km² (0.049/km²)	Carter *et al.* (2025) Windfarm Site (Carter *et al.*, 2022)	6,298 East Scotland (ES) MU (14,644)	Special Committee on Seals (SCOS) (2024) SCOS (2021)
			11,682 ES and Moray Firth (MF) MU (21,233)	
Harbour seal (*Phoca vitulina*)	0.000002/km² (0.000002/km²)	Carter *et al.* (2022)	383 ES MU (476)	
			1,748 ES and MF MU (1,972)	

4.4.1 C3: Auditory Injury and Disturbance Resulting from Underwater Noise during Piling, including Acoustic Deterrent Device (ADD) Activation

4.4.1.1 Existing Assessment of Effects of the Consented Project

4.4.1.1.1 Permanent Threshold Shift (PTS)

161. All marine mammals were assessed as having a high sensitivity for PTS from UWN as outlined in Section 11.7.4.4 of **Chapter 11: Marine Mammal Ecology** of the EIAR (GVOWL, 2023a)[§§§]. The impact of instantaneous PTS-onset was assessed as being of negligible magnitude for all species resulting in a minor adverse significance of effect (not significant) for all species assessed.

162. The impact magnitude for PTS due to cumulative sound exposure level (SEL_{cum}) due to the installation of one pin-pile without ADD activation was assessed as negligible, resulting in a minor adverse significance of effect (not significant) for harbour porpoise, minke whale and humpback whale, and no impact for dolphins and seals. The impact of PTS due to cumulative exposure of the installation of one pin-pile with 15 minutes ADD activation was concluded to have no impact for all marine mammals.

4.4.1.1.2 Temporary Threshold Shift (TTS)

163. All marine mammals were assessed as having a medium sensitivity for TTS from UWN as outlined in Section 11.7.4.4 of **Chapter 11: Marine Mammal Ecology** of the EIAR (GVOWL, 2023a). The impact of instantaneous TTS-onset from the soft-start and for the maximum hammer energy consented (2,300 kJ) was assessed as being of negligible magnitude for all species resulting in a minor adverse significance of effect (not significant).

164. The impact magnitude for TTS due to cumulative exposure of the installation of one pin-pile without ADD activation was assessed as negligible, resulting in minor adverse significance of effect (not significant) for harbour porpoise, humpback whale, grey seal and harbour seal and no impact for dolphin species. For minke whale, the magnitude was assessed as low, resulting in minor adverse significance of effect (not significant). The impact magnitude for TTS due to cumulative exposure of the installation of one pin-pile with 15 minutes ADD activation was assessed as negligible, resulting in minor adverse significance of effect (not significant) for harbour porpoise, minke whale and humpback whale, and no impact to dolphins and seals.

[§§§] See Section 11.7.4.4 in Chapter 11 in Green Volt EIAR (GVOWL, 2023) for definitions of sensitivity, magnitude and significance of effect.

4.4.1.1.3 Disturbance

165. All marine mammal species were assessed for potential behaviour disturbance due to piling, using conservative modelling assumptions and a range of assessment approaches (including UWN modelling, dose-response relationships and effective deterrent radii) as outlined in Section 11.7.5.3 of **Chapter 11: Marine Mammal Ecology** of the EIAR (GVOWL, 2023a). All species were assessed as having low or medium sensitivity. The predicted magnitude of impact ranged from negligible to low for all species except bottlenose dolphin. For bottlenose dolphin a high magnitude impact was predicted for a possible mild behavioural response, but this was considered a highly precautionary overestimate due to the species' predominantly coastal distribution which inherently reduces connectivity with the Windfarm Site.

166. Resulting effects were assessed as negligible to minor adverse for all species, except for bottlenose dolphin, for which a moderate adverse effect could not be ruled out under precautionary worst-case assumptions. In consultation with NatureScot, it was agreed that the use of the Coastal East Scotland (CES) MU for bottlenose dolphin was over precautionary, due to the distance (more than 80 km) of piling activity from the shore, and that residual effects of piling disturbance for bottlenose dolphin without mitigation were likely to be minor adverse (MD-LOT, 2023).

4.4.1.1.4 Potential Interaction with the Southern Trench Nature Conservation Marine Protected Area (NCMPA)

167. The 2023 EIAR (GVOWL, 2023a) identified that the Southern Trench Nature Conservation Marine Protected Area (NCMPA) was located over 50 km from the Windfarm Site, with piling activity limited to the installation of the OSP foundation (a maximum of four piles).

168. UWN modelling showed that all predicted thresholds for potential auditory injury (PTS and TTS) and behavioural disturbance to minke whale fell within the separation distance, and therefore did not overlap with the boundary of the Southern Trench NCMPA. The number of minke whales predicted to have been at risk of injury or disturbance represented a negligible proportion of the relevant reference population. Standard mitigation measures were identified, including the preparation of a Marine Mammal Mitigation Protocol (MMMP). Given the large separation distance between the Windfarm Site and the NCMPA, the limited nature and scale of piling activities, the fact that minke whale were more commonly found in the northern portion of the NCMPA, and the low number of minke whale individuals potentially affected, it was concluded that there would be no potential for impact on the minke whale population of the Southern Trench NCMPA.

4.4.1.2 Effects of the Proposed Variation

4.4.1.2.1 Permanent Threshold Shift (PTS)

169. For marine mammals, the risk of PTS has been evaluated using the Southall *et al.* (2019) criteria, as detailed in **Table 4.6**.

Table 4.6 PTS onset thresholds for marine mammals exposed to impulsive noise (Southall et al., 2019)

Species	Species Group	Instantaneous PTS Threshold Unweighted SPL_{peak} (dB re1 µPa)	Cumulative PTS Threshold Weighted SEL_{cum} (dB re 1 $\mu Pa^2 s$)
Harbour porpoise	Very high frequency (VHF)	202	155
Bottlenose dolphin	High frequency (HF)	230	185
White-beaked dolphin			
Atlantic white-sided dolphin			
Risso's dolphin			
Minke whale	Low frequency (LF)	219	183
Humpback whale			
Fin whale			
Grey seal	Phocid carnivores in Water (PCW)	218	185
Harbour seal			

4.4.1.2.1.1 Instantaneous PTS

170. The revised instantaneous PTS impact ranges for marine mammals have been calculated for the first strike with a starting hammer energy of 300 kJ and the phase of piling with maximum peak sound energy level (maximum hammer energy of 3,500 kJ) (see **Appendix C** for details of the UWN modelling) and are presented in **Table 4.7** in comparison with modelled ranges in the 2023 EIAR (GVOWL, 2023a). The differences in impact ranges noted for first hammer strike, between the 2023 EIAR (GVOWL, 2023a) and the Proposed Variation are a result of the updated UWN modelling approach, as set out in **Appendix C**.

Table 4.7 Maximum instantaneous PTS onset impact ranges due to the first hammer strike and maximum peak sound pressure level, modelled for the Project EIAR (GVOWL, 2023a) (displayed in blue) and updated for Proposed Variation (2025 – see Appendix C)

Species	Instantaneous PTS Impact Ranges in Project EIAR (2023a)		Instantaneous PTS Impact Ranges updated for the Proposed Variation	
	First Hammer Strike (300 kJ)	Maximum Peak Sound Pressure Level (Max Hammer Energy 2,300 kJ)	First Hammer Strike (300 kJ)	Maximum Peak Sound Pressure Level (Max Hammer Energy 3,500 kJ)
Harbour porpoise	170 m (0.091 km^2)	234 m (0.172 km^2)	579 m (1.05 km^2)	1,996 m (12.14 km^2)
Bottlenose dolphin	13 m (0.00053 km^2)	18 m (0.0010 km^2)	33 m (0.001 km^2)	117 m (0.43 km^2)
White-beaked dolphin				
Atlantic white-sided dolphin				
Risso's dolphin				
Minke whale	35 m (0.0038 km^2)	49 km (0.0075 km^2)	82 m (0.021 km^2)	431 m (1.28 km^2)
Humpback whale				
Fin whale				
Grey seal	39 m (0.0048 km^2)	54 m (0.0092 km^2)	90 m (0.095 km^2)	139 m (0.061 km^2)
Harbour seal				

171. The maximum impact ranges and areas for instantaneous PTS (**Table 4.7**) have been used to estimate the maximum number of individuals and percentage of the relevant reference population that could be impacted based on updated modelling for the Proposed Variation (**Table 4.8**).

172. The detailed evaluation for the Proposed Variation indicates that less than one individual of any species could be at risk of instantaneous PTS, with the exception of harbour porpoise, where up to ten individuals could potentially be impacted (0.003 % of the North Sea (NS) MU). The magnitude of the potential impact is assessed as low for harbour porpoise and for the CES MU population of bottlenose dolphin. For all other marine mammal species the magnitude is assessed as negligible, with less than 0.001 % of the relevant reference populations anticipated to be exposed to any permanent effect (**Table 4.8**).

173. The effect significance is moderate adverse for harbour porpoise based on high sensitivity for PTS from UWN. However, this is without mitigation. The effect significance is minor adverse for all other marine mammals.

174. The maximum potential instantaneous PTS ranges for all marine mammal species will be mitigated with the procedures presented in the MMMP, which must be submitted to Scottish Ministers for approval at least six months before commencement of construction, to reduce the risk of permanent auditory injury during piling works. The mitigation protocol will include ADD activation prior to the first strike. Following ADD activation, it can be assumed that marine mammals would no longer be present within instantaneous PTS ranges, thereby reducing any risk of instantaneous PTS in all marine mammal species. Therefore, the significance of effect would be minor adverse (not significant) for harbour porpoise, the CES MU population of bottlenose dolphin, and all other marine mammal species (**Table 4.8**).

Table 4.8 Evaluation of the potential for instantaneous PTS, including with mitigation, based on updated modelling for Proposed Variation (assessment from Project EIAR (GVOWL, 2023a) is displayed in blue, Projects significance of effect- bolded) (UK MU portion presented for reference only, as per paragraph 160)

Species	Maximum Number of Individuals (% of MU)		Magnitude (Permanent Impact)		Sensitivity	Effect Significance		Effect Significance with Mitigation
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation	
Harbour porpoise	0.13 (0.000038% NS MU)	10 (0.003% NS MU)	Negligible	Low	High	Minor adverse	Moderate adverse	**Minor adverse**
	Not assessed	10 (0.006% NS MU UK Portion)	Not assessed	Low	High	Not assessed	Moderate adverse	**Minor adverse**
Bottlenose dolphin	0.00003 (0.0000015% GNS MU & 0.000014% CES MU)	0.001 (0.00007% GNS MU & 0.0006 CES MU)	Negligible (Negligible CES MU)	Negligible (Negligible CES MU)	High	Minor adverse	Minor adverse	**Minor adverse**
	Not assessed	0.001 (0.00006% GNS MU UK Portion)	Not assessed	Negligible	High	Not assessed	Minor adverse	**Minor adverse**
White-beaked dolphin	0.0002 (0.00000056 % CGNS MU)	0.004 (0.000008% GCNS MU)	Negligible	Negligible	High	Minor adverse	Minor adverse	**Minor adverse**
	Not assessed	0.004 (0.00001% GCNS MU UK Portion)	Not assessed	Negligible	High	Not assessed	Minor adverse	**Minor adverse**

Species	Maximum Number of Individuals (% of MU)		Magnitude (Permanent Impact)		Sensitivity	Effect Significance		Effect Significance with Mitigation
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation	
Atlantic white-sided dolphin	0.00003 (0.00000016 % CGNS MU)	0.001 (0.000004% GCNS MU)	Negligible	Negligible	High	Minor adverse	Minor adverse	**Minor adverse**
	Not assessed	0.001 (0.000005% GCNS MU UK Portion)	Not assessed	Negligible	High	Not assessed	Minor adverse	**Minor adverse**
Risso's dolphin	0.000002 (0.000000015 % CGNS MU)	0.003 (0.00002% GCNS MU)	Negligible	Negligible	High	Minor adverse	Minor adverse	**Minor adverse**
	Not assessed	0.003 (0.00003% GCNS MU UK Portion)	Not assessed	Negligible	High	Not assessed	Minor adverse	**Minor adverse**
Minke whale	0.0003 (0.0000015% CGNS MU)	0.03 (0.0001% GCNS MU)	Negligible	Negligible	High	Minor adverse	Minor adverse	**Minor adverse**
	Not assessed	0.03 (0.0002% GCNS MU UK Portion)	Not assessed	Negligible	High	Not assessed	Minor adverse	**Minor adverse**
Humpback whale	0.0000001 (0.000000000 3% NA MU)	0.00001(0.00 000003% NA MU)	Negligible	Negligible	High	Minor adverse	Minor adverse	**Minor adverse**
Fin whale	Not assessed	0.001 (0.00008% NA MU)	Not assessed	Negligible	High	Not assessed	Minor adverse	**Minor adverse**

Species	Maximum Number of Individuals (% of MU)		Magnitude (Permanent Impact)		Sensitivity	Effect Significance		Effect Significance with Mitigation
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation	
Grey seal	0.0004 (0.000003% ES MU & 0.000002% ES & MF MU)	0.01 (0.0002% ES MU & 0.0001 ES & MF MU)	Negligible	Negligible	High	Minor adverse	Minor adverse	**Minor adverse**
Harbour seal	0. 00000002 (0.000000004 % ES MU & 0.000000000 9% ES & MF MU)	0.0000001 (0.00000003 ES MU & 0.000000007 % ES & MF MU)	Negligible	Negligible	High	Minor adverse	Minor adverse	**Minor adverse**

4.4.1.2.1.2 Cumulative PTS from the Installation of a Single Pin Pile

175. The cumulative sound exposure level (SEL_{cum}) is a measure of the total received sound energy over the duration of piling. The impact ranges based on SEL_{cum} impact thresholds are related to the fleeing speed of the marine mammal. At any location within the SEL_{cum} impact range, if an individual begins fleeing in a straight line away from the noise source at the onset of piling, it will still receive enough sound energy to be impacted (see **Appendix C** for further details).

176. The piling parameters, including duration of soft-start, ramp-up procedure, strike rate, number of strikes and duration, were selected to reduce the potential impact ranges, as much as possible, for PTS from cumulative exposure (see **Appendix C** for the soft-start and ramp-up parameters used in the updated UWN modelling).

177. The maximum impact ranges for cumulative PTS exposure during the installation of a single pin-pile, installed within a 24-hour period, for the OSP for each species group is presented in **Table 4.9**, both with and without 15 minutes ADD activation.

178. **Table 4.9** presents impact ranges for marine mammals, from the EIAR (GVOWL, 2023a) and the updated UWN modelling results (see **Appendix C**). The predicted impact range for baleen whale has increased (**Table 4.9**), and as a result the modelled 15 minute ADD activation time is not long enough to ensure baleen whales are out of the required mitigation zone. Therefore, the MMMP will be updated to reflect this. With 15 minute ADD activation harbour porpoise would be outwith the impact range. The impact ranges for dolphins and seals are less than the threshold (N/E = threshold not exceeded), with and without ADD activation, indicating that no exceedance is expected for the given criteria based on the results of the modelling which means that noise levels from piling have minimal risk of auditory injury from cumulative PTS to dolphins and seals.

Table 4.9 Maximum PTS impact ranges based on the cumulative SEL metric for marine mammals due to cumulative exposure from the installation of a single OSP pin-pile in a 24-hour period with and without 15 minute ADD activation (N/E = threshold not exceeded). (Results from 2023 EIAR (GVOWL, 2023a) displayed in blue)

Species	Cumulative PTS Impact Ranges in Project EIAR (2023a)		Cumulative PTS Impact Ranges updated for the Proposed Variation	
	Without ADD Activation	With 15 Minutes ADD Activation	Without ADD Activation	With 15 Minutes ADD Activation
Harbour porpoise	227 m (0.162 km^2)	N/E	520 m (0.85 km^2)	N/E
Bottlenose dolphin	N/E	N/E	N/E	N/E
White-beaked dolphin				
Atlantic white-sided dolphin				
Risso's dolphin				
Minke whale	1,085 m (3.698 km^2)	N/E	3,059 m (29.4 km^2)	958 m (2.88 km^2)
Humpback whale				
Fin whale				
Grey seal	N/E	N/E	N/E	N/E
Harbour seal				

179. These predicted impact ranges have been used to estimate the maximum number of individuals and percentage of the relevant reference population that could be impacted from cumulative PTS for installation of single OSP pin-pile in a 24-hour period (**Table 4.10**).

180. For all dolphin and seal species, there is no risk of PTS from the cumulative exposure for the installation of a single OSP pin-pile in a 24-hour period, without ADD activation.

181. Without ADD activation, harbour porpoise, minke whale, humpback whale, and fin whale are at potential risk of PTS from cumulative exposure for the installation of single OSP pin-pile in a 24-hour period. The magnitude of the potential impact is assessed as negligible, minor adverse (not significant) for harbour porpoise, humpback whale, and fin whale, with less than 0.001 % of the relevant reference populations anticipated to be exposed to any permanent effect (**Table 4.10**). The magnitude of the potential PTS for minke whale is assessed as low resulting in an effect significance of moderate adverse (significant) for the Celtic and Greater North Sea (CGNS) MU without mitigation.

182. However, with mitigation, by applying 15 minutes of ADD activation prior to soft-start commencing, only baleen whales (minke, humpback, and fin whale) could still be at risk of PTS as a result of the cumulative exposure during the installation of a single OSP pin-pile in a 24-hour period (**Table 4.10**). With ADD mitigation, the magnitude of the potential impact is assessed as negligible for all baleen whales, with less than 0.001 % of the relevant reference populations anticipated to be exposed to any permanent effect (**Table 4.10**).

183. This evaluation assumes that during the 15 minutes ADD activation prior to piling, marine mammals would flee directly away from the pile location (at the speeds of 1.5 m/s for VHF, 1.52 m/s for HF, 2.3 m/s for LF species and 1.8 m/s for PCW; see **Appendix C** for details). The effect significance is minor adverse (not significant), based on high sensitivity for PTS from UWN for all marine mammal species (**Table 4.10**).

184. The maximum potential cumulative PTS ranges for all marine mammal species will be mitigated through the implementation of the measures within the MMMP, which must be submitted to Scottish Ministers for approval at least six months before commencement of construction. The MMMP will include ADD activation prior to the first strike to ensure all marine mammals, including baleen whales, would be beyond the maximum cumulative PTS impact range for each species. Therefore, following mitigation, it can be assumed that marine mammals would no longer be present within cumulative PTS ranges, thereby reducing any risk of cumulative PTS in all marine mammal species, resulting in minor adverse effect significance for all marine mammals (**Table 4.10**).

Table 4.10 Evaluation of the potential for PTS based on the cumulative SEL metric for marine mammals due to cumulative exposure from the installation of single OSP pin-pile in 24-hour period with and without 15 minute ADD activation (N/E = threshold not exceeded). (Assessment from GV EIAR (GVOWL, 2023a) displayed in blue Projects significance of effect- bolded) (UK MU portion presented for reference only, as per paragraph 160)

Species	Maximum Number of Individuals (% of MU)		Magnitude		Sensitivity	Significance of Effect		Mitigation	Significance of Effect
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation		Proposed Variation
Without ADD Activation									
Harbour porpoise	0.12 (0.00004% NS MU)	0.06 (0.00002 % NS MU)	Negligible	Negligible	High	Minor adverse	Minor adverse	Without mitigation	**Minor adverse**
	Not assessed	0.06 (0.00004 % NS MU UK Portion)	Not assessed	Negligible		Not assessed	Minor adverse		**Minor adverse**
Bottlenose dolphin	N/E	N/E	N/E	N/E	High	No Impact	No Impact	Without mitigation	**No Impact**
White-beaked dolphin									
Atlantic white-sided dolphin									
Risso's dolphin									
Minke whale	0.14 (0.0007% CGNS MU)	<2 (1.2) (0.006% CGNS MU)	Negligible	Low	High	Minor adverse	Moderate adverse	Without mitigation	**Minor adverse**

Species	Maximum Number of Individuals (% of MU)		Magnitude		Sensitivity	Significance of Effect		Mitigation	Significance of Effect
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation		Proposed Variation
	Not assessed	<2 (1.2) (0.011% CGNS MU UK Portion)	Not assessed	Medium		Not assessed	Major adverse		**Minor adverse**
Humpback whale	0.00006 (0.00000016 % NA MU)	0.0004 (0.000001 % NA MU)	Negligible	Negligible	High	Minor adverse	Minor adverse	Without mitigation	**Minor adverse**
Fin whale	Not assessed	0.03 (0.0008% NA MU)	Not assessed	Negligible	High	Not assessed	Minor adverse	Without mitigation	**Minor adverse**
Grey seal	N/E	N/E	N/E	N/E	High	No Impact	No Impact	Without mitigation	**No Impact**
Harbour seal	N/E		N/E			No Impact			

Species	Maximum Number of Individuals (% of MU)		Magnitude		Sensitivity	Significance of Effect		Mitigation	Significance of Effect
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation		Proposed Variation
With 15 minute ADD activation									
Harbour porpoise	N/E	N/E	N/E	N/E	High	N/E	No Impact	Mitigation measures outlined in MMMP	**No Impact**
Bottlenose dolphin **White-beaked dolphin** **Atlantic white-sided dolphin** **Risso's dolphin**	N/E	N/E	N/E	N/E	High	N/E	No Impact	Mitigation measures outlined in MMMP	**No Impact**
Minke whale	N/E	0.1 (0.0006% CGNS MU)	N/E	Negligible	High	N/E	Minor adverse	Mitigation measures outlined in MMMP	**Minor adverse**
	Not assessed	0.1 (0.001% CGNS MU UK Portion)	Not assessed	Low		Not assessed	Moderate adverse		**Minor adverse**
Humpback whale	N/E	0.00004 (0.0000001% NA MU)	N/E	Negligible	High	No Impact	Minor adverse	Mitigation measures outlined in MMMP	**Minor adverse**

Species	Maximum Number of Individuals (% of MU)		Magnitude		Sensitivity	Significance of Effect		Mitigation	Significance of Effect
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation		Proposed Variation
Fin whale	Not assessed	0.003 (0.00008 % NA MU)	Not assessed	Negligible	High	Not assessed	Minor adverse	Mitigation measures outlined in MMMP	**Minor adverse**
Grey seal	N/E	N/E	N/E	N/E	High	No Impact	No Impact	Mitigation measures outlined in MMMP	**No Impact**
Harbour seal									**No Impact**

4.4.1.2.1.3 Cumulative PTS from the Installation of Consecutive Pin Piles

185. The SEL_{cum} is a measure of the total received sound energy over the duration of piling. The impact ranges based on SEL_{cum} impact thresholds are related to the fleeing speed of the marine mammal (see **Appendix C** for further details).

186. The piling parameters, including duration of soft-start, ramp-up procedure, strike rate, number of strikes and duration, were selected to reduce the potential impact ranges, as much as possible, for PTS from cumulative exposure (see **Appendix C** for the soft-start and ramp-up parameters used in the UWN modelling).

187. The maximum impact ranges for cumulative PTS exposure during consecutive installation of pin-piles installed within a 24-hour period for the OSP (likely to be maximum of four pin-piles per 24-hour period) for each species group is presented in **Table 4.11** both with and without 15 minutes ADD activation.

Table 4.11 Maximum PTS impact ranges based on the cumulative SEL metric for marine mammals due to cumulative exposure from the consecutive installation of OSP pin-piles in 24-hour period with and without 15 minute ADD activation (N/E = threshold not exceeded)

Species	Cumulative PTS Impact Ranges for the Proposed Variation	
	Without ADD Activation	With 15 Minutes ADD Activation
Harbour porpoise	527 m (0.87 km²)	N/E
Bottlenose dolphin	N/E	N/E
White-beaked dolphin		
Atlantic white-sided dolphin		
Risso's dolphin		
Minke whale	4,611 m (66.79 km²)	2,529 m (20.09 km²)
Humpback whale		
Fin whale		
Grey seal	5 m (<0.00008 km²)	N/E
Harbour seal		

188. This evaluation assumes that during the 15 minutes ADD activation prior to piling, marine mammals would flee directly away from the pile location, (at the speeds of 1.5 m/s for VHF, 1.52 m/s for HF, 2.3 m/s for LF species and 1.8 m/s for PCW; see **Appendix C** for details). The effect significance is minor adverse (not significant) for harbour porpoise, humpback whale, grey and harbour seal, based on high sensitivity for PTS from UWN without the use of an ADD, with no impact for dolphin species (**Table 4.12**). With no ADD activation, the effect significance is major for minke whale and moderate for fin whale, respectively (**Table 4.12**).

189. With 15 minutes of ADD, it is predicted that there would be no impact to harbour porpoise, dolphins and seals (**Table 4.12**). The effect significance is minor adverse (not significant) for humpback whale and fin whale, and moderate adverse for minke whale (**Table 4.12**). Therefore, the modelled 15 minute ADD activation is not long enough to reduce the risk of cumulative PTS from consecutive pin-pile installation in a 24-hour period for minke whale. As such the ADD activation time prior to the first strike will be increased to approximately 34 minutes to ensure all baleen whales, including minke whale, would be beyond the maximum cumulative PTS impact range. Therefore, following mitigation, as outlined in the updated MMMP, which must be submitted to Scottish Ministers for approval at least six months before commencement of construction, it can be assumed that marine mammals would no longer be present within cumulative PTS ranges, thereby reducing any risk of cumulative PTS in all marine mammal species.

Table 4.12 Evaluation of the potential for PTS based on the cumulative SEL metric for marine mammals due to cumulative exposure from the consecutive installation of OSP pin-piles in 24-hour period with and without 15 minute ADD activation (Projects significance of effect- bolded) (N/E = threshold not exceeded) (UK MU portion presented for reference only, as per paragraph 160)

Species	Maximum Number of Individuals (% of MU)	Magnitude	Sensitivity	Significance of Effect	Mitigation	Significance of Effect
Without ADD activation						
Harbour porpoise	1.0 (0.0002% NS MU)	Negligible	High	Minor adverse	Without mitigation	**Minor adverse**
	1.0 (0.0004% NS MU UK Portion)	Negligible		Minor adverse		**Minor adverse**
Bottlenose dolphin	N/E	N/E		No Impact		**No Impact**
White-beaked dolphin						
Atlantic white-sided dolphin						
Risso's dolphin						
Minke whale	3 (0.01% CGNS MU	Medium		Major adverse		**Major adverse**
	3 (0.03% CGNS MU UK Portion)	Medium		Major adverse		**Major adverse**
Humpback whale	0.001 (0.000003% NA MU)	Negligible	High	Minor adverse	Without mitigation	**Minor adverse**
Fin whale	0.06 (0.002% NA MU)	Low	High	Moderate adverse	Without mitigation	**Moderate adverse**
Grey seal	0.001 (0.00002% ES MU; 0.00001% ES & MF MU)	Negligible	High	Minor adverse	Without mitigation	**Minor adverse**

Species	Maximum Number of Individuals (% of MU)	Magnitude	Sensitivity	Significance of Effect	Mitigation	Significance of Effect
Harbour seal	0.00000001(0.00000000004% ES MU; 0.000000000008% ES & MF MU)	Negligible	High	Minor adverse	Without mitigation	**Minor adverse**
With 15 minute ADD activation						
Harbour porpoise	N/E	N/E	High	No Impact	Mitigation measures outlined in the MMMP	**No Impact**
Bottlenose dolphin **White-beaked dolphin** **Atlantic white-sided dolphin** **Risso's dolphin**	N/E	N/E	High	No Impact	Mitigation measures outlined in the MMMP	**No Impact**
Minke whale	1 (0.0006% CGNS MU	Negligible	High	Minor adverse	Mitigation measures outlined in the MMMP	**Minor adverse**
	1 (0.008% CGNS MU UK Portion)	Low		Moderate adverse		**Minor adverse**
Humpback whale	0.0003 (0.0000009% NA MU)	Negligible	High	Minor adverse	Mitigation measures outlined in the MMMP	**Minor adverse**
Fin whale	0.02 (0.0005% NA MU)	Negligible	High	Minor adverse	Mitigation measures outlined in the MMMP	**Minor adverse**
Grey seal **Harbour seal**	N/E	N/E	High	No Impact	Mitigation measures outlined in the MMMP	**No Impact**

4.4.1.2.2 Temporary Threshold Shift

190. For marine mammals, the risk of TTS has been assessed using the Southall *et al.* (2019) criteria (**Table 4.13**). TTS can occur instantaneously from acute exposure to high noise levels, such as single strike (SEL_{ss}) of the maximum hammer energy applied during piling. TTS can also occur because of prolonged exposure to increased noise levels, such as during the duration of pile installation (SEL_{cum}).

Table 4.13 TTS onset thresholds for marine mammals exposed to impulsive noise (Southall et al., 2019)

Species	Species Group	Instantaneous TTS Threshold Unweighted SPL_{peak} (dB re1 μPa)	Cumulative TTS Threshold Weighted SEL_{cum} (dB re 1 $\mu Pa^2 s$)
Harbour porpoise	VHF	196	140
Bottlenose dolphin	HF	224	170
White-beaked dolphin			
Atlantic white-sided dolphin			
Risso's dolphin			
Minke whale	LF	213	168
Humpback whale			
Fin whale			
Grey seal	PCW	212	170
Harbour seal			

4.4.1.2.2.1 Instantaneous TTS

191. The updated instantaneous TTS impact ranges for marine mammals have been calculated for the first strike with a starting hammer energy of 300 kJ and the phase of piling with maximum peak sound energy level (maximum hammer energy of 3,500 kJ) (see **Appendix C** for details of the UWN modelling) and are presented in **Table 4.14** in comparison with modelled ranges in the EIAR (GVOWL, 2023a). The differences in impact ranges noted for first hammer strike, between the 2023 EIAR (GVOWL, 2023a) and the Proposed Variation are a result of the updated UWN modelling approach, as set out in **Appendix C**.

Table 4.14 Maximum instantaneous TTS onset impact ranges due to the first hammer strike and the maximum peak sound pressure level modelled for the Project EIAR (2023a) and updated for the Proposed Variation

Species	Instantaneous TTS Impact Ranges in Project EIAR (2023a)		Instantaneous TTS Impact Ranges updated for the Proposed Variation	
	First Hammer Strike (300 kJ)	Maximum Peak Sound Pressure Level (Max Hammer Energy 2,300 kJ)	First Hammer Strike (300 kJ)	Maximum Peak Sound Pressure Level (Max Hammer Energy 3,500 kJ)
Harbour porpoise	295 m (0.273 km²)	407 m (0.52 km²)	621 m (1.21 km²)	2,839 m (25.32km²)
Bottlenose dolphin	22 m (0.0015km²)	31 m (0.003 km²)	54 m (0.009 km²)	195 m (0.12 km²)
White-beaked dolphin				
Atlantic white-sided dolphin				
Risso's dolphin				
Minke whale	62 m (0.012 km²)	85 m (0.023 km²)	134 m (0.056 km²)	639 m (1.28 km²)
Humpback whale				
Fin whale				
Grey seal	68 m (0.015 km²)	93 m (0.027 km²)	150m (1.78 km²)	752 m (1.78 km²)
Harbour seal				

192. The maximum impact ranges for instantaneous TTS (**Table 4.14**) for each species has been used to estimate the maximum number of individuals and percentage of the relevant reference population that could be impacted (**Table 4.15**).

193. Up to 20 harbour porpoise (0.006 % of the NS MU) could be at risk of instantaneous TTS due to maximum hammer strike (3,500 kJ). For all other marine mammals, less than one individual could be at risk of instantaneous TTS. For all marine mammals, including harbour porpoise, the magnitude in the updated evaluation is negligible, with medium sensitivity, resulting in minor adverse significance of effect (not significant) (**Table 4.15**).

Table 4.15 Evaluation of the potential for instantaneous TTS (Assessment from Project EIAR (GVOWL, 2023a) displayed in blue, Projects significance of effect- bolded) (UK MU portion presented for reference only, as per paragraph 160)

Species	Maximum Number of Individuals (% of MU)		Magnitude (Temporary Impact)		Sensitivity	Effect Significance	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
Harbour porpoise	0.4 (0.0001% NS MU)	20 (0.006% NS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
	Not assessed	20 (0.01% NS MU UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Bottlenose dolphin	0.00009 (0.0000044% the GNS MU & 0.000040%the CES MU)	0.004 (0.0002% GNS MU & 0.002% CES MU))	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
	Not assessed	0.004 (0.0002% GNS MU UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
White-beaked dolphin	0.0007 (0.0000017% CGNS MU)	0.01 (0.00002% CGNS MU UK Portion)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**

Species	Maximum Number of Individuals (% of MU)		Magnitude (Temporary Impact)		Sensitivity	Effect Significance	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
	Not assessed	0.01 (0.00002% CGNS MU UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Atlantic white-sided dolphin	0.00008 (0.00000047% CGNS MU)	0.002 (0.00001% CGNS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
	Not assessed	0.002 (0.00001% CGNS MU UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Risso's dolphin	0.000005 (0.00000004% CGNS MU)	0.01 (0.00002% CGNS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
	Not assessed	0.01 (0.00007% CGNS MU UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Minke whale	0.0009 (0.000004% CGNS MU)	0.05 (0.00026% CGNS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**

Species	Maximum Number of Individuals (% of MU)		Magnitude (Temporary Impact)		Sensitivity	Effect Significance	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
	Not assessed	0.05 (0.0003% CGNS MU UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Humpback whale	0.0000003 (0.000000001% NA MU)	0.00002 (0.0000001% NA MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
Fin whale	Not assessed	0.001 (0.00003% NA MU)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Grey seal	0.0013 grey seal (0.0000091% of the ES MU; 0.0000063% ES & MF MU)	0.4 (0.006% ES MU & 0.003% ES & MF MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
Harbour seal	0.00000005 harbour seal (0.000000011%of the ES MU; 0.0000000028% ES & MF MU)	0.000004 (0.0000009% ES MU & 0.0000002% ES & MF MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**

4.4.1.2.2.2 Cumulative TTS from the Installation of a Single Pin Pile

194. **Table 4.16** presents the cumulative TTS impact ranges and areas for marine mammals, from the 2023 EIAR (GVOWL, 2023a) and the updated UWN modelling results (see **Appendix C** for details of the UWN modelling).

Table 4.16 Maximum TTS impact ranges based on the cumulative SEL metric for marine mammals due to cumulative exposure from the installation of single OSP pin-pile in 24-hour period with and without 15 minute ADD activation (N/E = threshold not exceeded) (Assessment from Project EIAR (GVOWL, 2023a) displayed in blue)

Species	Cumulative TTS Impact Ranges in the Project EIAR (GVOWL, 2023a)		Cumulative TTS Impact Ranges updated for the Proposed Variation	
	Without ADD Activation	With 15 Minutes ADD Activation	Without ADD Activation	With 15 Minutes ADD Activation
Harbour porpoise	3,580 m (40.264 km^2)	2,190 m (15.067km^2)	6,432 m (129.97 km^2)	5,082 m (81.14 km^2)
Bottlenose dolphin White-beaked dolphin Atlantic white-sided dolphin Risso's dolphin	N/E	N/E	18 m (0.01 km^2)	N/E
Minke whale Humpback whale Fin whale	41,900 m (5,515.411 km^2)	39,800 m (4,976.408 km^2)	65,587 m (13,514 km^2)*	64,170 m (12,936 km^2)*
Grey seal Harbour seal	1,245 m (4.870 km^2)	N/E	3,045 m (29.13 km^2)	1,411 m (6.25 km^2)

** These ranges are likely an overestimate due to the noise at this range no longer being impulsive as described in* ***Appendix C***

195. As stated in **Section 4.4.1.2.1.2** the SEL_{cum} is a measure of the total received sound energy over the duration of piling, accounting for the fleeing speed of an individual marine mammal receptor (see **Appendix C** for further details). The piling parameters to determine the predicted impact ranges for TTS from cumulative exposure are presented in **Appendix C**.

196. The maximum impact ranges for cumulative TTS exposure during the installation of a single pin-pile installed in a 24-hour period for the OSP are presented in **Table 4.16** for each species group, both without and with 15 minutes ADD activation. These predicted impact ranges have been used to estimate the maximum number of individuals and percentage of the relevant reference population that could be impacted (**Table 4.17**).

197. For minke whale, without the use of an ADD, up to 2.8 % of the CGNS MU could be temporary effected (2.7 % with 15 minute ADD activation), resulting in a low magnitude, minor adverse effect (not significant). However, this is deemed very over precautionary because for high intensity noise sources such as pile driving, when propagating through a medium over 65 km, the level of impulsiveness reduces. Therefore prior to 65 km, the impulsive sound source is likely to change into a non-impulsive sound source, this is explained further in **Appendix C**.

198. Although the magnitude for potential cumulative TTS (with and without ADD) is low for minke whale, with medium sensitivity, resulting in a minor adverse effect (non-significant) (**Table 4.17**), this is over precautionary. It should be noted that TTS ranges are very precautionary, an article by Southall (2021) discusses this aspect in detail, and notes that "*…when onset criteria levels were applied to relatively high-intensity impulsive sources (e.g. pile driving), TTS onset was predicted in some instances at ranges of tens of kilometres from the sources. In reality, acoustic propagation over such ranges transforms impulsive characteristics in time and frequency (see Hastie et al. 2019; Amaral et al. 2020; Martin et al., 2020). Changes to received signals include less rapid signal onset, longer total duration, reduced crest factor, reduced kurtosis, and narrower bandwidth (reduced high-frequency content). A better means of accounting for these changes can avoid overly precautionary conclusions, although how to do so is proving vexing*". The point is reinforced later in the discussion which points out that "*…it should be recognised that the use of impulsive exposure criteria for receivers at greater ranges (tens of kilometres) is almost certainly an overly precautionary interpretation of existing criteria*". This acoustic wave elongation effect is particularly pronounced at larger ranges of several kilometres and, in particular, it is considered highly unlikely that predicted PTS or TTS ranges for impulsive noise which are found to be in the tens of kilometres are realistic (Southall, 2021); (see **Appendix C** for more information).

199. For all other marine mammals, the potential risk of TTS (with and without ADD) is assessed as negligible, with medium sensitivity, resulting in an effect significance of minor adverse (not significant) (**Table 4.17**).

200. This evaluation assumes that during the ADD activation prior to piling, marine mammals would flee directly away from the pin-pile location, at the speeds outlined in **Appendix C**. ADD activation is part of the mitigation protocol, therefore with mitigation, the risk of TTS from cumulative exposure would be reduced. Mitigation measures for piling are described in the MMMP, which must be submitted to Scottish Ministers for approval at least six months before commencement of construction.

Table 4.17 Evaluation of the potential for TTS based on the cumulative SEL metric for marine mammals due to cumulative exposure from the installation of single OSP pin-pile in 24-hour period with and without 15 minute ADD activation (Assessment from Project EIAR (2023a) is displayed in blue, Projects significance of effect- bolded) (N/E = threshold not exceeded) (UK MU portion presented for reference only, as per paragraph 160)

Species	Maximum Number of Individuals (% of MU)		Magnitude (Temporary Impact)		Sensitivity	Significance of Effect	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
Without ADD Activation							
Harbour porpoise	30.6 (0.009% NS MU)	99 (0.03% NS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
	Not assessed	99 (0.06% NS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Bottlenose dolphin	N/E	0.0003 (0.00001% GNS MU; 0.0001% CES MU)	N/E	Negligible	Medium	No Impact	**Minor adverse**
	Not assessed	0.0003 (0.00002% GNS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
White-beaked dolphin	N/E	0.0008 (0.000002% CGNS MU)	N/E	Negligible	Medium	No Impact	**Minor adverse**
	Not assessed	0.0008 (0.000002% CGNS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Atlantic white-sided dolphin	N/E	0.0002 (0.000001% CGNS MU)	N/E	Negligible	Medium	No Impact	**Minor adverse**

Species	Maximum Number of Individuals (% of MU)		Magnitude (Temporary Impact)		Sensitivity	Significance of Effect	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
	Not assessed	0.0002 (0.000001% CGNS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Risso's dolphin	N/E	0.0007 (0.000006% CGNS MU)	N/E	Negligible	Medium	No Impact	**Minor adverse**
	Not assessed	0.0007 (0.000008% CGNS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Minke whale	213.5 (1.06% CGNS MU)	566 (2.8% CGNS MU)	Low	Low	Medium	Minor adverse	**Minor adverse**
	Not assessed	566 (5.5% CGNS MU, UK Portion)	Not assessed	Medium	Medium	Not assessed	Moderate adverse **(Minor adverse****)**
Humpback whale	0.08 (0.00024% NA MU)	0.2 (0.0006% NA MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
Fin whale	Not assessed	12 (0.4% NA MU)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**

**** Due to information presented in paragraph 198, assigning the significance effect as moderate adverse is felt to be over precautionary due to the reduction in impulsiveness of the sound at distances greater than 10 km. The sound is very unlikely to be impulsive at 50 to 60 km away from source.

Species	Maximum Number of Individuals (% of MU)		Magnitude (Temporary Impact)		Sensitivity	Significance of Effect	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
Grey seal	0.24 (0.0016% ES MU; 0.0011% ES & MF MU	6 (0.1% ES MU; 0.05% ES & MF MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
Harbour seal	0.00001 (0.000002% ES MU; 0.0000005% ES & MF MU)	0.0001 (0.00002% ES MU; 0.000003% ES & MF MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
With 15 minute ADD activation							
Harbour porpoise	11.5 (0.003% NS MU)	62 (0.02% of NS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
	Not assessed	62 (0.04% of NS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Bottlenose dolphin	N/E	N/E	N/E	N/E	Medium	No Impact	**No Impact**
White-beaked dolphin							
Atlantic white-sided dolphin							
Risso's dolphin							
Minke whale	193 (0.95% GCNS MU)	542 (2.7% CGNS MU)	Negligible	Low	Medium	Minor adverse	**Minor adverse**
	Not assessed	542 (5.5% CGNS MU, UK Portion)	Not assessed	Medium	Medium	Not assessed	Moderate adverse **(Minor adverse****)**

Species	Maximum Number of Individuals (% of MU)		Magnitude (Temporary Impact)		Sensitivity	Significance of Effect	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
Humpback whale	0.08 (0.0002% NA MU)	0.2 (0.0006% NA MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
Fin whale	Not assessed	12 (0.35% NA MU)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Grey seal	N/E	1.3 (0.2% ES MU; 0.01% ES & MF MU)	N/E	Negligible	Medium	No impact	**Minor adverse**
Harbour seal	N/E	0.00001 (0.000003% ES MU; 0.0000007% ES & MF MU)	N/E	Negligible	Medium	No impact	**Minor adverse**

4.4.1.2.2.3 Cumulative TTS from the Installation of Consecutive Pin Piles

201. The maximum impact ranges for cumulative TTS exposure during consecutive installation of pin-piles installed within a 24-hour period for the OSP (likely to be maximum of four pin piles per 24 hour period) for each species group is presented in **Table 4.18** both with and without 15 minutes ADD activation (see **Appendix C** for details of the UWN modelling).

Table 4.18 Maximum TTS impact ranges based on the cumulative SEL metric for marine mammals due to cumulative exposure from the consecutive installation of four OSP pin-piles in 24-hour period with and without 15 minute ADD activation (N/E = threshold not exceeded)

Species	Cumulative TTS Impact Ranges updated for the Proposed Variation	
	Without ADD Activation	With 15 Minutes ADD Activation
Harbour porpoise	7,221 m (164 km^2)	5,870 m (108 km^2)
Bottlenose dolphin	17 m (0.00009 km^2)	N/E
White-beaked dolphin		
Atlantic white-sided dolphin		
Risso's dolphin		
Minke whale	>65,000 m (13,273 km^2)*	>65,000 m (13,273 km^2)*
Humpback whale		
Fin whale		
Grey seal	4,675 m (68.66 km^2)	3.051 m (29.24 km^2)
Harbour seal		

These ranges are likely an overestimate due to the noise at this range no longer being impulsive as described in* ***Appendix C*

202. This evaluation assumes that during the 15 minutes ADD activation prior to piling, marine mammals would flee directly away from the pile location, (at the speeds of 1.5 m/s for VHF, 1.52 m/s for HF, 2.3 m/s for LF species and 1.8 m/s for PCW; see **Appendix C**). The magnitude is negligible, with a 15 minute ADD activation, for all marine mammal species, except for minke whale, with medium sensitivity, the resulting effect significance is minor adverse (not significant (**Table 4.19**). The magnitude is assessed as medium for minke whale resulting in moderate adverse (significant) effect. However, as stated in **Section 4.4.1.2.2.2**, the TTS ranges that exceed tens of kilometres are suggested to be over precautionary due to the level of impulsiveness (kurtosis) changing as the impulsive sound propagates, making the kurtosis levels decrease, turning the sound into a non-impulsive sound at a distance closer than 65 km.

Table 4.19 Evaluation for the potential for TTS based on the cumulative SEL metric for marine mammals due to cumulative exposure from the consecutive installation of four OSP pin-piles in 24-hour period with and without 15 minute ADD activation (Projects significance of effect- bolded) (UK MU portion presented for reference only, as per paragraph 160)

Species	Maximum Number of Individuals (% of MU	Magnitude (Temporary Impact)	Sensitivity	Significance of Effect
Without ADD Activation				
Harbour porpoise	125 (0.04% NS MU)	Negligible	Medium	**Minor adverse**
	125 (0.07% NS MU, UK Portion)	Negligible	Medium	**Minor adverse**
Bottlenose dolphin	0.000003 (0.0000001% GNS MU & 0.000001% CES MU)	Negligible	Medium	**Minor adverse**
	0.000003 (0. 0000001% GNS, UK portion			
White-beaked dolphin	0.00001 (0.00000002% CGNS MU & CGNS, UK portion)			
	0.00001 (0.00000002% CGNS MU, UK portion)			
Atlantic white-sided dolphin	0.0002 (0.000001% CGNS MU)			
	0.0002 (0.000002% CGNS MU, UK Portion)			
Risso's dolphin	0.00001 (0.0000001% CGNS MU)			
	0.00001 (0.0000001% CGNS MU, UK Portion)			
Minke whale	556 (2.8% CGNS MU)	Low	Medium	**Minor adverse**

Species	Maximum Number of Individuals (% of MU	Magnitude (Temporary Impact)	Sensitivity	Significance of Effect
	556 (5.4% CGNS MU, UK Portion)	Medium	Medium	Moderate adverse **(Minor adverse****)**
Humpback whale	0.2 (0.0006% NA MU)	Negligible	Medium	**Minor adverse**
Fin whale	12 (0.4% NA MU)	Negligible	Medium	**Minor adverse**
Grey seal	6 (0.1% ES MU; 0.05% ES & MF MU)	Negligible	Medium	**Minor adverse**
Harbour seal	0.0001(0.00004% ES MU; 0.000008% ES & MF MU)	Negligible	Medium	**Minor adverse**
With 15 Minute ADD Activation				
Harbour porpoise	82 (0.02% NS MU)	Negligible	Medium	**Minor adverse**
	82 (0.05% NS MU, UK Portion)	Negligible	Medium	**Minor adverse**
Bottlenose dolphin	-	-	Medium	No Impact
White-beaked dolphin				
Atlantic white-sided dolphin				
Risso's dolphin				
Minke whale	556 (2.7% CGNS MU)	Low	Medium	**Minor adverse**
	556 (5.4% CGNS MU, UK Portion)	Medium	Medium	Moderate adverse **(Minor adverse****)**
Humpback whale	0.2 (0.0006% NA MU)	Negligible	Medium	**Minor adverse**
Fin whale	12 (0.4% NA MU)	Negligible	Medium	**Minor adverse**
Grey seal	1 (0.02% (ES MU; 0.01% ES & MF MU)	Negligible	Medium	**Minor adverse**
Harbour seal	0.00001 (0.000003% (ES MU; 0.0000007% ES & MF MU)	Negligible	Medium	**Minor adverse**

4.4.1.2.3 Behavioural Disturbance

203. The potential disturbance from UWN during piling for all marine mammal species has been assessed based on the National Marine Fisheries Service (NMFS) (2005; 2018) Level B harassment threshold of 160 dB re 1 μPa (Root Mean Square (rms)) for impulsive sound (see **Section 4.4.1.2.3.2**). In addition, the Effective Deterrent Ranges (EDR) have been used for harbour porpoise (see **Section 4.4.1.2.3.3**) and the dose-response curve has been applied for harbour porpoise, bottlenose dolphin (to represent all dolphin species as worst case), minke whale (to represent all baleen whales as worst case), grey seal and harbour seal (see **Section 4.4.1.2.3.4**).

4.4.1.2.3.1 Disturbance from ADD

204. The swim speed of marine mammal species groups used in this evaluation and for the UWN modelling are summarised in **Table 4.20.**

Table 4.20 Marine mammal swim speeds used for the evaluation

Species	Hearing Group	Swim Speed	Reference
Harbour porpoise	VHF	1.5	Otani *et al.* (2000)
Dolphin	HF	1.52	Bailey and Thompson (2010)
Baleen whale	LF	2.3	Boisseau *et al.* (2021)
Seal	PCV	1.8	Thompson *et al.* (2015)

205. Based on minke whale swim speed of 2.3 m/s, the ADD would need to be activated for at least 34 minutes for minke whale to be beyond the predicted cumulative PTS impact range of 4,611 m (**Table 4.11**). This increased activation time would also ensure harbour porpoise were beyond the maximum potential impact range for instantaneous PTS of 1,966 m (**Table 4.7**). The ADD activation time is higher in comparison with the 15 minutes that was required from the UWN modelling in the 2023 EIAR (GVOWL, 2023a). A comparison is presented in **Table 4.21**.

Table 4.21 Comparison of ADD activation time and deterrent ranges (2023 EIAR (GVOWL, 2023a) is displayed in blue)

Species	ADD Activation Time		Deterrent Range of Marine Mammal	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation
Harbour porpoise	15 minutes	34 minutes	1.35 km	3.06 km
Dolphin			1.36 km	3.10 km
Baleen whale			2.07 km	4.69 km
Seal			1.62 km	3.67 km

206. The use of an ADD for 34 minutes has the potential to cause disturbance. Therefore, the evaluation for disturbance during ADD activation is based on 34 minutes, and the swim speed of the marine mammals (**Table 4.20**).

207. **Table 4.22** presents the potential disturbance range for each species which has been calculated from the ADD activation time and the animals swim speed for the Proposed Variation and results from 15 minute ADD activation from the 2023 EIAR (GVOWL, 2023a) for comparison. **Table 4.22** shows that there is no change in the effect significance, as even with a slight increase of ADD activation, the significance of effect remains negligible adverse (not significant) for all marine mammal species.

Table 4.22 Potential for disturbance during ADD activation prior to pin-pile installation (Assessment from Project EIAR (GVOWL, 2023a) displayed in blue, Projects significance of effect- bolded)

Species	Potential Disturbance Area		Maximum number of individuals (% of MU)		Magnitude	Sensitivity	Effect Significance
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation			
Harbour porpoise	1.35 km (5.73 km^2)	3.06 km (29.42 km^2)	5 (0.001% of NS MU)	23 (0.006% of NS MU)	Negligible	Low	**Negligible adverse**
			Not assessed	23 (0.007% of NS MU, UK Portion)	Negligible	Low	**Negligible adverse**
Bottlenose dolphin	1.36 km (5.88 km^2)	3.10 km (30.21 km^2)	0.2 (0.01% GNS MU & 0.01% CES MU)	0.9 (0.04% GNS MU & 0.4% CES MU)	Negligible	Low	**Negligible adverse**
			Not assessed	0.9 (0.05% GNS MU, UK Portion)	Negligible	Low	**Negligible adverse**
White-beaked dolphin			0.5 (0.001% CGNS MU)	3 (0.005% CGNS MU)	Negligible	Low	**Negligible adverse**
			Not assessed	(0.007% CGNS MU, UK Portion)	Negligible	Low	**Negligible adverse**
Atlantic white-sided dolphin			0.1 (0.0004% CGNS MU)	0.4 (0.002% CGNS MU)	Negligible	Low	**Negligible adverse**

Species	Potential Disturbance Area		Maximum number of individuals (% of MU)		Magnitude	Sensitivity	Effect Significance
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation			
			Not assessed	0.4 (0.003% CGNS MU, UK Portion)	Negligible	Low	**Negligible adverse**
Risso's dolphin			0.4 (0.003% CGNS MU)	2 (0.02% CGNS MU)	Negligible	Low	**Negligible adverse**
			Not assessed	2 (0.02% CGNS MU, UK Portion)	Negligible	Low	**Negligible adverse**
Minke whale	2.07 km (13.46 km^2)	4.69 km (69.16 km^2)	1 (0.003% CGNS MU)	3 (0.01% CGNS MU)	Negligible	Low	**Negligible adverse**
			Not assessed	3 (0.03% CGNS MU)	Negligible	Low	**Negligible adverse**
Humpback whale	2.07 km (13.46 km^2)		0.0002 (0.0000001% NA MU)	0.001 (0.000003% NA MU)	Negligible	Low	**Negligible adverse**
Fin whale	2.07 km (13.46 km^2)		0.01 (0.0004% NA MU)	0.06 (0.002% NA MU)	Negligible	Low	**Negligible adverse**
Grey seal	1.62 km (8.24 km^2)	3.67 km (42.36 km^2)	2 (0.03% ES MU & 0.015% ES & MF MU)	9 (0.1% ES MU & 0.07% ES & MF MU)	Negligible	Low	**Negligible adverse**

Species	Potential Disturbance Area		Maximum number of individuals (% of MU)		Magnitude	Sensitivity	Effect Significance
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation			
Harbour seal			0.00002 (0.000004% ES MU & 0.0000009% ES & MF MU)	0.00008 (0.00002% ES MU & 0.000005% ES & MF MU)	Negligible	Low	**Negligible adverse**

4.4.1.2.3.2 Disturbance based on the Underwater Noise Modelling

208. The UWN modelling (**Appendix C**) is based on a conservative approach and uses the NMFS (2018) Level B harassment threshold of 160 dB re 1 µPa rms for impulsive sound. Level B Harassment is defined by NMFS (2005) 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 is similar to the JNCC *et al*. (2010a) description of non-trivial disturbance and has therefore been used as the basis for potential behavioural change in this detailed evaluation.

209. It is important to understand that exposure to sound levels in excess of the behavioural change threshold does not necessarily imply that the sound will result in significant disturbance. The detailed evaluation considers the likelihood that the sensitive receptors will be exposed to that sound, the duration of exposure and whether the numbers exposed are likely to be significant at the population level. Results of the UWN modelling based on the 160 dB threshold for disturbance or possible behavioural response are provided in **Table 4.23**. The predicted impact range is 17.77 km (992.03 km^2) which is an increase from 3.491 km (38.287 km^2) which was assessed in the EIAR (GVOWL, 2023a). Even with the increase in predicted disturbance range, the assessment has resulted in the same significance of effect, minor adverse (not significant) for all marine mammal species. With exception to the CES bottlenose dolphin MU, which is assessed as major adverse (significant). However, through consultation with NatureScot during the EIAR, it was stated that including the CES MU into the assessment was over precautionary as they are generally found close to shore (within 3 km) and in shallow water (<20 m) (NatureScot, 2021). Therefore, any disturbance to the CES MU from UWN from piling has been assessed as minor adverse (not significant).

Table 4.23 Maximum number of individuals (and % of Reference Population) that could be at risk of disturbance from the installation of pin piles for the OSP using the 160 dB disturbance threshold (Assessment from Project EIAR (GVOWL, 2023a) displayed in blue) (Projects significance of effect- bolded)

Species	Impact Range/Area		Maximum Number of Individuals (% of MU)		Magnitude		Sensitivity	Effect Significance	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
Harbour porpoise	3.491 km (38.287 km^2)	17.77 km (992.03 km^2)	29.1 (0.008% of NS MU)	754 (0.21% of NS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
			Not assessed	754 (0.47% of NS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Bottlenose dolphin			1.14 (0.056% GNS MU & 0.51% CES MU)	30 (1.5% GNS MU & 13% CES MU)	Negligible	Low (GNS MU) and High (CES MU)	Medium	Minor adverse	**Minor adverse**[††††]
			Not assessed	30 (1.6% GNS MU, UK Portion)	Not assessed	Low	Medium	Not assessed	**Minor adverse**

[††††] Although the assessment calculates to major adverse with regard to the CES MU, due to previous consultation with NatureScot during the Project EIAR (GVOWL, 2023a), this was deemed over precautionary due to the fact that the CES MU are unlikely to be found beyond 3 km from shore (NatureScot, 2021), therefore, the true effect significance for CES MU is deemed to be Minor adverse (not significant).

Species	Impact Range/Area		Maximum Number of Individuals (% of MU)		Magnitude		Sensitivity	Effect Significance	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
White-beaked dolphin			9.3 (0.021% CGNS MU)	79 (0.18% CGNS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
			Not assessed	79 (0.23% CGNS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Atlantic white-sided dolphin			1.1 (0.0059% CGNS MU)	15 (0.07% CGNS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
			Not assessed	15 (0.1% CGNS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Risso's dolphin			0.07 (0.00056% CGNS MU)	70 (0.56% CGNS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
			Not assessed	70 (0.8% CGNS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Minke whale			1.5 (0.0074% CGNS MU)	42 (0.20% CGNS MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**

Species	Impact Range/Area		Maximum Number of Individuals (% of MU)		Magnitude		Sensitivity	Effect Significance	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
			Not assessed	42 (0.4% CGNS MU, UK Portion)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Humpback whale			0.0006 (0.0000016% NA MU)	0.01 (0.000001% NA MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
Fin whale			Not assessed	1 (0.03% NA MU)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Grey seal			1.9 (0.013% ES MU & 0.0088% ES & MF MU)	199 (3.2% ES MU & 1.7% ES & MF MU)	Negligible	Low	Medium	Minor adverse	**Minor adverse**
Harbour seal			0.00008 (0.000016% ES MU & 0.0000039% ES & MF MU)	0.002 (0.0005% ES MU & 0.0001% ES & MF MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**

4.4.1.2.3.3 Disturbance based on the Effective Deterrence Radius Approach for Harbour Porpoise

210. The current advice in England, Wales and Northern Ireland from Statutory Nature Conservation Bodies (JNCC, Department of Agriculture, Environment and Rural Affairs, and Natural England) (JNCC *et al*., 2020) is that a potential disturbance range (EDR) is used to assess the area that harbour porpoise may be disturbed in within harbour porpoise designated Special Areas of Conservation in English waters (JNCC *et al.,* 2020). For pin-piles, with and without noise abatement, the EDR is 15 km (a potential disturbance area of up to 706.9 km^2). While the Windfarm Site is not located in close proximity to these designated sites, the approach has been used for information purposes only. Not all harbour porpoise within the potential disturbance areas based on EDR will be disturbed, however as the WCS 100 % disturbance of harbour porpoise in the area has been assumed.

211. The effect significance is negligible adverse (not significant) for harbour porpoise using the disturbance of a 15 km EDR approach (**Table 4.24**), as presented in Table 11.57 of 2023 EIAR (GVOWL, 2023a).

Table 4.24 Evaluation for potential disturbance using the 15 km EDR approach for harbour porpoise from the installation of OSP pin-piles (Projects significance of effect- bolded)

Species	Impact Range/Area	Maximum Number of Individuals (% of MU)	Magnitude	Sensitivity	Effect Significance
Harbour porpoise	15 km (706.9 km^2)	538 (0.155% of NS MU)	Negligible	Medium	**Minor adverse**
		538 (0.3% of NS MU, UK Portion)	Negligible	Medium	**Minor adverse**

4.4.1.2.3.4 Disturbance based on Dose-Response Curve

212. Following current best practice guidance (Southall *et al*., 2021), a behavioural disturbance dose-response analysis has been carried out for those species for which appropriate dose-response evidence exists within the scientific literature. For methods, see Section 11.7.4.1 of the 2023 EIAR (GVOWL, 2023a).

213. The dose-response relationship used for harbour porpoise was developed by Graham *et al*. (2017) using data collected on harbour porpoises during Phase 1 of piling at the Beatrice Offshore Wind farm (Figure 11.18 of 2023 EIAR (GVOWL, 2023a) and for the Proposed Variation has been applied to all other cetaceans as there are no dose-response relationships currently available in the literature for any other cetacean.

214. For both harbour seal and grey seal, a dose-response relationship, derived from harbour seal telemetry data collected during several months of piling at the Lincs Offshore Wind Farm, has been used (Whyte *et al*., 2020, (Figure 11.19 of 2023 EIAR (GVOWL, 2023a).

215. The 2023 EIAR (GVOWL, 2023a) applied dose-response curves to harbour porpoise, grey seal, and harbour seal. Therefore, a comparison between the Proposed Variation and the 2023 EIAR (GVOWL, 2023a) can only be made for these species. The estimated numbers (and percentage of the relevant MU) of marine mammals that could be disturbed as a result of UWN during piling of the OSP pin-piles are presented in **Table 4.25**.

216. The significance of effect for disturbance from UWN due to piling has been assessed as minor adverse (not significant) for all marine mammals. The application of the harbour porpoise dose-response curve to SCANS III bottlenose dolphin densities would initially suggest an effect significance of moderate adverse for the Greater North Sea (GNS) MU (significant) and major adverse for the CES MU (significant) (**Table 4.25**). However, this is deemed over precautionary as the dose-response curve applied to bottlenose dolphin is based on the hearing sensitivity of harbour porpoise, which are known to be more sensitive to disturbance from UWN. In addition, it is unlikely that the CES MU population would be within the vicinity of piling at the OSP, within the Windfarm Site, due to being generally found close to shore (within 3 km) and in shallow water (<20 m) (NatureScot, 2021). Therefore, with the consideration of these factors, it is considered the significance of effect for bottlenose dolphin to be minor adverse (not significant).

Table 4.25 Number of individuals (and % of reference population) that could be disturbed during piling based on the dose-response curve (Assessment from Project EIAR (GVOWL, 2023a) displayed in blue, Projects significance of effect- bolded)

Species	Number of Individuals Disturbed (% of Reference Population)		Magnitude		Sensitivity	Significance of Effect	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
Harbour porpoise	451 (0.13% of NS MU)	4,899 (1.4% of NS MU)	Negligible	Low	Medium	Minor adverse	**Minor adverse**
	Not assessed	4,899 (3% of NS MU, UK Portion)	Not assessed	Low	Medium	Not assessed	**Minor adverse**
Bottlenose dolphin	Not assessed	149 (7.3% GNS MU & 66% CES MU)	Not assessed	Medium (GNS MU) and High (CES MU)	Medium	Not assessed	**Minor adverse**[‡‡‡‡]
		149 (8% GNS MU, UK portion)		Medium	Medium	Not assessed	**Minor adverse**[‡‡‡‡]
White-beaked dolphin	Not assessed	1,044 (3% CGNS MU)	Not assessed	Low	Medium	Not assessed	**Minor adverse**
		1,044 (2.4% CGNS MU, UK Portion)		Low	Medium		**Minor adverse**
Atlantic white-sided dolphin	Not assessed	53 (0.3% CGNS MU)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
		53 (0.4% CGNS MU, UK Portion)		Minor adverse	Minor adverse		**Minor adverse**

[‡‡‡‡] Although the assessment states moderate and major adverse, due to previous consultation with NatureScot during the Project EIAR (GVOWL, 2023a), this was deemed over precautionary due to the fact that bottlenose dolphin are unlikely to be found beyond 3 km from shore (NatureScot, 2021), therefore, the true effect significance for both the GNS MU and CES MU is deemed to be Minor adverse (not significant).

Species	Number of Individuals Disturbed (% of Reference Population)		Magnitude		Sensitivity	Significance of Effect	
	In Project EIAR (2023a)	Proposed Variation	In Project EIAR (2023a)	Proposed Variation		In Project EIAR (2023a)	Proposed Variation
Risso's dolphin	Not assessed	255 (2% CGNS MU)	Not assessed	Minor adverse	Minor adverse	Not assessed	**Minor adverse**
		255 (3% CGNS MU, UK Portion)		Low	Medium		**Minor adverse**
Minke whale	Not assessed	253 (1.3% CGNS MU)	Not assessed	Low	Medium	Not assessed	**Minor adverse**
		253 (2.5% CGNS MU, UK Portion)		Low	Medium		**Minor adverse**
Humpback whale	Not assessed	0.1(0.0004% NA MU)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Fin whale	Not assessed	5 (0.14% NA MU)	Not assessed	Negligible	Medium	Not assessed	**Minor adverse**
Grey seal	3 (0.019% ES MU & 0.013% ES & MF MU)	231 (0.76% ES MU & 0.41% ES & MF MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**
Harbour seal	0.0002 (0.00004 & 0.00001% ES MU & % ES & MF MU)	0.3 (0.08% ES MU & 0.02% ES & MF MU)	Negligible	Negligible	Medium	Minor adverse	**Minor adverse**

4.4.1.2.4 Assessment for the Southern Trench NCMPA

217. The Conservation and Advice document for the Southern Trench NCMPA (NatureScot, 2020) states that, for any piling operations, the impacts from UWN should be decreased, either by using Noise Abatement Systems (NAS), or pile management strategies, such as the mitigation guidelines for piling developed by JNCC (2010b). Given the nature and scale of the piling at the Windfarm Site, with the water depth of 100 - 115 m, the limited number of pin-piles, and the piling location (OSP) is located 50.9 km from the closest point of Southern Trench NCMPA (which is located in the southern portion of the MPA north-east of Peterhead), the use of NAS would not be appropriate.

218. Only the predicted TTS impact ranges for minke whale would overlap with the Southern Trench NCMPA, however, it is likely that the noise from piling at that distance would be considered more on a non-impulsive sound and is likely to be very low in volume, so any impact to the NCMPA would be minimal. Furthermore, the distribution of minke whales is more concentrated in the northern areas of the NCMPA (MD-LOT, 2023), which are beyond any calculated range of impact in this Proposed Variation:

- PTS single strike of maximum hammer energy (3,500 kJ) = 431 m;
- PTS cumulative exposure for installation of a single pin-pile, without ADD = 3.059 km;
- PTS cumulative exposure for installation of a of consecutive pin-piles, without ADD = 4.611 km;
- TTS single strike of maximum hammer energy (3,500 kJ) = 639 m;
- TTS cumulative exposure for installation of a single pin-pile, without ADD = 65.587 km;
- TTS cumulative exposure for installation of a of consecutive pin-piles, without ADD = <65 km; and
- Disturbance/ possible behavioural response (160 dB threshold) = 17.77 km.

219. In total, less than one (0.03) minke whale, equating to 0.0001 % of the CGNS MU that may be at risk of PTS for single strike (**Table 4.8**) and less than two (0.006 % of the CGNS MU) for the cumulative exposure of the installation of a single pin pile (**Table 4.10**) respectively. For the cumulative exposure of the installation of consecutive pin piles, up to three minke whales could be at risk of PTS, equating to 0.01 % of the reference population (**Table 4.12**).

220. In total up to 566 individuals could be at risk of TTS, (2.8 % of the CGNS MU), (**Table 4.17** and **Table 4.19**). However, this is deemed as over precautionary because the UWN modelling does not take into account of level of impulsiveness (kurtosis) of the sound, as that is known to decrease significantly in distances over 10 km (Southall et al., 2021). For more information see **Appendix C** for details of the precautions built into the UWN modelling).

221. Up to 42 (0.2 % of the CGNS MU) minke whale could be disturbed using the 160 dB threshold (**Table 4.23**), or 253 (1.3 % of the CGNS MU) using the dose-response curve assessment (**Table 4.25**) (bearing in mind this involves the application of a harbour porpoise dose-response curve and so must be treated with caution). Any disturbance will be temporary and localised, therefore unlikely to cause any significant effects.

222. Any impacts to minke whale as a result of piling would be minor adverse. Taking into account the mitigation that will be undertaken for piling (see MMMP), and the low number of minke whale at risk of PTS, it is not expected that there would be any potential for significant effect to the minke whale population in relation to the Southern Trench NCMPA due to piling activities.

4.4.1.2.5 Conclusion and EIA Screening Outcome

223. With the Proposed Variation in the Project design, the predicted impact ranges for marine mammals have increased compared to the predicted impact ranges presented in the 2023 EIAR (GVOWL, 2023a) which is likely due to the increase in hammer energies, but also reflects developments in the UWN modelling approach since the modelling was undertaken for the 2023 EIAR (GVOWL, 2023a) (see **Appendix C** for details).

224. The risk of potential auditory injury (PTS and TTS) to marine mammals, following mitigation, remains the same in comparison with the 2023 EIAR (GVOWL, 2023a).

225. For marine mammal mitigation, in the 2023 EIAR (GVOWL, 2023a), ADD activation time was 15 minutes, which was sufficient to deter all marine mammals out of the predicted impact area/mitigation zone for PTS, based on the modelling at that time. With the updated UWN modelling results for the Proposed Variation, the ADD is now recommended to be activated for 34 minutes to ensure all marine mammals are out of the mitigation zone. The MMMP will be updated to address this.

226. The risk of potential disturbance due to UWN from piling has been assessed as minor adverse for all marine mammals. Using the harbour porpoise dose-response curve for bottlenose dolphin results in a moderate and major adverse effect for bottlenose dolphins, but this is deemed as over precautionary as harbour porpoise are more sensitive to UWN and bottlenose dolphin are considered unlikely to be found beyond 3 km from shore (NatureScot, 2021). Taking these factors into account, disturbance due to UWN from piling is assessed as minor adverse for bottlenose dolphin in line with all other marine mammal species evaluated.

227. In accordance with the Schedule 3 criteria of the EIA Regulations the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall nature and scale. The location of the development is unchanged, and the receiving environment, while used by a range of marine mammal species, is not considered to be of elevated or unique sensitivity in relation to this impact pathway. The characteristics of the impact pathway and its spatially constrained nature, remain comparable to those previously assessed with the use of mitigation. There is no material change to the magnitude of the impact or the residual effect of this impact pathway because of the Proposed Variation. Therefore, the impact pathway for auditory injury and disturbance resulting from UWN during piling, including ADD activation, is screened out of further EIA.

4.4.2 C7: Barrier Effects as a Result of Underwater Noise

228. UWN during construction could have the potential to create a barrier effect, preventing movement or migration of marine mammals between important feeding and / or breeding areas, or potentially increasing swimming distances if marine mammals avoid the area and go around it. All marine mammals have been considered to have a medium sensitivity for barrier effects due to underwater as outlined in Section 11.7.4.4 of **Chapter 11: Marine Mammals** of the 2023 EIAR (GVOWL, 2023a).

4.4.2.1 Existing Assessment of Effects of the Consented Project

229. The potential impact of barrier effects as a result of UWN was assessed with a negligible magnitude for all marine mammal species, resulting in a minor adverse significance effect (not significant) in the EIAR (GVOWL, 2023a). There is unlikely to be any significant long-term impacts from any barrier effects, as any areas affected would be relatively small in comparison to the range of marine mammals and would not be continuous throughout the offshore construction period.

4.4.2.2 Effects of the Proposed Variation

230. There has been no change in the assessment of the significance effect with the Proposed Variation in the Project design. There is unlikely to be any significant long-term impacts from any barrier effects, as any areas affected would be relatively small in comparison to the range of marine mammals and would not be continuous throughout the offshore construction period. The assessment remains the same as that presented in Section 11.7.5.7 of **Chapter 11: Marine Mammals** of the 2023 EIAR (GVOWL, 2023a) with minor adverse effect significance (not significant). The Proposed Variation does not materially alter the magnitude of the impact, or the residual effect identified in the original assessment.

4.4.2.3 Conclusion and EIA Screening Outcome

231. In accordance with the Schedule 3 criteria of the EIA regulations the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall nature and scale. The location of the development is unchanged, and the receiving environment, while used by a range of marine mammal species, is not considered to be of elevated or unique sensitivity in relation to this impact pathway. The characteristics of the impact pathway and its spatially constrained nature, remain comparable to those previously assessed. There is no material change to the magnitude of the impact or the residual effect of this impact pathway as a result of the Proposed Variation. This impact pathway is therefore screened out of further EIA.

4.4.3 O5: Potential Entanglement with Mooring Lines

4.4.3.1 Existing Assessment of Effects of the Consented Project

232. The consented Project includes up to 210 mooring lines, with each WTG having six mooring lines, constructed from chain, mooring cable, and/or polyester, depending on the final design. The mooring lines, for the catenary system, have a maximum radius of 650 m, whilst the mooring tendons for the TLP have a maximum radius of 100 m. The mooring lines are tensioned at all times, with no slack or looped sections present. This inherently reduces the potential for entanglement.

233. At the time of the assessment, no marine mammal entanglements had been recorded with floating WTG mooring systems or comparable anchored Floating Production, Storage and Offloading vessel moorings. The design of the Project's moorings, including their diameter, stiffness, and consistent tension, meant that receptor sensitivity to direct entanglement was considered negligible for all marine mammal species.

234. The assessment identified that the greater risk to marine mammals came from secondary (and tertiary) entanglement. Secondary entanglement could occur if marine debris (particularly lost fishing gear) became tangled around mooring lines and/or mid-water (i.e., inter-array) cables, or other infrastructure, and subsequently entangled marine wildlife. Tertiary entanglement is where marine debris or active fishing gear entangles a marine mammal offsite, and that debris or fishing gear then becomes entangled on the infrastructure or mooring lines as the animal transits through the Offshore Development Area. Both can cause the animal to be anchored underwater, unable to take any breaths which can cause death.

235. Minke whale, humpback whale and fin whale were considered most sensitive to secondary entanglement (high sensitivity), based on entanglement data from fisheries. Other receptors, including small-toothed whales (including dolphins and harbour porpoise) and seal species, were assessed as having lower susceptibility (negligible sensitivity) due to their small size and greater manoeuvrability. Accounting for receptor sensitivity and mooring system characteristics, the impact magnitude was determined to range from negligible to low (minke whale, humpback whale and fin whale). Initial effect significance was determined to be negligible to minor for small-toothed whales and seal species, and negligible to moderate for minke whale, humpback whale and fin whale, respectively.

236. Due to the identified evidence gap relating to potential entanglement (direct, secondary, and tertiary) in floating offshore wind mooring infrastructure, monitoring protocols will be fully outlined in the Project Environment Monitoring Programme (PEMP), which must be submitted to Scottish Ministers for approval at least six months before commencement of construction. These monitoring protocols are considered to be effective in reducing the potential risk and therefore magnitude of the impact such that the residual effect of the impact pathway was determined to be negligible adverse to minor adverse and therefore not significant in regard to the EIA Regulations.

4.4.3.2 Effects of the Proposed Variation

237. The Proposed Variation increases the total length of mooring lines deployed across the Project from 137 km to 315 km. This change results from an increase in the mooring line radius for the mooring system from 650 m to 1,000 m and an increase in the maximum number of mooring lines per WTG from six to nine. The maximum number of WTGs remains unchanged at 35 and the fundamental characteristics of the mooring system remain as previously assessed.

238. The potential entanglement mechanism, particularly factors relevant to marine mammals remains unchanged. No new mechanisms for direct, secondary, or tertiary entanglement have been introduced as a result of the Proposed Variation. Importantly, all mooring infrastructure remains confined to the same Windfarm Site (116 km^2), this is a spatially constrained area relative to the extensive ranges of marine mammal species, such as minke whale, humpback whale and fin whale that range over hundreds to thousands of kilometres. As such, whilst the spatial footprint of the Project's mooring system has increased, this does not equate to a material change to the nature or overall magnitude of the impact, given that the entanglement pathway and species sensitivity remain consistent with the original assessment.

239. The PEMP remains in place and will continue to provide robust protocols for monitoring potential entanglement risk, including investigation of marine debris and gear interaction with the mooring system. This will support the continued development of the evidence base relating to the potential for secondary entanglement, as although mooring lines have been used for platforms in the oil and gas industry, data is scare which could indicate a low likelihood of secondary entanglement and therefore a low sensitivity of most marine mammals.

240. The Proposed Variation does not materially alter the magnitude of the impact, or the residual effect identified in the original assessment.

4.4.3.3 Conclusion and EIA Screening Outcome

241. In accordance with the Schedule 3 criteria of the EIA regulations the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall nature and scale. The location of the development is unchanged, and the receiving environment, while used by a range of marine mammal species, is not considered to be of elevated or unique sensitivity in relation to this impact pathway. The characteristics of the impact pathway, including the mooring system’s lack of high entanglement risk characteristics (no slack or looped sections), and its spatially constrained nature, remain comparable to those previously assessed.

242. There is no material change to the magnitude of the impact or the residual effect of this impact pathway as a result of the Proposed Variation. This impact pathway is therefore screened out of further EIA.

4.5 Offshore and Intertidal Ornithology

243. Following the initial screening process presented in **Section 3** and **Appendix A**, the impact pathways listed in **Table 4.26** have been brought forward for detailed evaluation. For each impact pathway, the table presents a comparison of the WCS parameters defined in **Chapter 12: Offshore Ornithology** of the 2023 EIAR (GVOWL, 2023a) with those relevant to the Proposed Variation. As outlined in **Section 1.4.3**, the WCS parameters reflect both the Windfarm Site infrastructure and the OECs, where relevant, which is consistent with the approach adopted in the 2023 EIAR (GVOWL, 2023a). As the Proposed Variation relates only to infrastructure within the Windfarm Site and no changes are proposed to the OECs, the WCS parameters for the OECs remain unchanged. No new impact pathways for this topic have been identified in relation to the Proposed Variation.

244. To understand how the key parameter changes, summarised in **Table 4.26**, may alter the potential risk of collision to key seabirds, CRM for the consented WCS and proposed varied design envelope WCS scenarios has been undertaken. The details of additional CRM completed to support the conclusions within this Screening Report are provided within **Appendix B**.

Table 4.26 Summary of the screened in offshore and intertidal ornithology impact pathways and associated worst-case scenarios

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
O5: Collision risk: Array **O6: Combined operational displacement and collision risk**	**Key parameters:** • WTG deployment across the full Windfarm Site (116 km^2); • Maximum number of WTGs: 35; • Maximum blade tip height above MSL: 264 m; • Minimum blade tip clearance above MSL: 22 m; • Maximum rotor blade radius: 121 m; • Maximum blade width: 8 m; and • Under the precautionary principle, displacement is assumed to occur across the entire extent of the Windfarm Site red line boundary.	**Scenario 1: 35 x 14 MW WTGs (**with power boost option to 15 MW**)** **Key parameters:** • WTG deployment across the full Windfarm Site (116 km^2); • Maximum number of WTGs: 35; • Maximum blade tip height above MSL: 266 m; • Minimum blade tip clearance above SWL: 22 m; • Maximum rotor blade radius: 118 m; and • Maximum blade width: 6.5 m. **Scenario 2: 30 x 18.5 MW WTGs** **Key Parameters:** • WTG deployment across the full Windfarm Site (116 km^2); • Maximum number of WTGs: 30; • Maximum blade tip height above MSL: 289 m; • Minimum blade tip clearance above SWL: 22 m; • Maximum rotor blade radius: 130 m; and • Maximum blade width: 6.81 m.	**Key parameters:** The varied design envelope includes two scenarios: Scenario 1 (35 x 14 MW WTGs) and Scenario 2 (30 x 18.5 MW WTGs), both of which have been evaluated in updated CRM (**Appendix B**). While rotor diameter increases in Scenario 2 (130 m vs 121 m (consented)), the reduction in WTG maximum number and blade width (from 8.5 m (consented) to 6.81 m) results in a decrease in maximum total rotor swept area compared to the consented design envelope. Scenario 1 has a reduced blade radius (118 m) and narrower blades (6.5 m). As such, revised CRM indicates a reduction in predicted collision risk compared to the consented design for both scenarios.

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
		<u>Displacement Relevant to Scenario 1 and Scenario 2</u> • Under the precautionary principle, displacement is assumed to occur across the entire extent of the Windfarm Site red line boundary.	

4.5.1 O5: Collision Risk: Array & O6: Combined Operational Displacement and Collision Risk

4.5.1.1 Existing Assessment of Effects of the Consented Project

245. **Chapter 12: Offshore Ornithology** of the 2023 EIAR (GVOWL, 2023a) concluded a total of four different seabird species potentially at risk of collision with the Project:

- Black-legged kittiwake (*Rissa tridactyla*);
- Northern gannet (*Morus bassanus*);
- Herring gull (*Larus argentatus*); and
- Great black-backed gull (*Larus marinus*).

246. These species were subsequently included within CRM as detailed within in **Appendix 12.3: Offshore Ornithology Collision Risk Modelling** (GVOWL, 2023a). Based on the level of annual impact predicted, the significance of effect was concluded to be minor adverse at most for all receptors. Post application submission, a Supplementary Ornithological Assessment Report (GVOWL, 2023d) was produced to provide updated assessment conclusions when following NatureScot's published guidance notes to support offshore wind applications assessment of marine ornithology receptors (NatureScot, updated 2025). These guidance notes were published after the Project's application submission and contained significant updates to recommended parameters and approaches to CRM. The updated modelling predicted a reduction in collision risk for black-legged kittiwake and northern gannet, whereas collision risk for herring gull and great black-backed gull increased compared to impact predictions within the EIAR (GVOWL, 2023a). In relation to the large gull species the predicted increase in impact related to changes in recommended biological modelling parameters rather than due to change in WTG design, as no design changes were made. However, the changes in impact predictions did not materially change the conclusion of minor adverse significance at most for all species.

247. In the case of combined collision risk and displacement, through application of the precautionary principle, it was assumed that displacement occurred at the level of the red line boundary for the Windfarm Site. The 2023 EIAR (GVOWL, 2023a) concluded a total of two different seabird species potentially at risk of displacement from the Project:

- Black-legged kittiwake; and
- Northern gannet.

248. While both impact pathways, collision risk and displacement, can interact, the assessment acknowledged the potential for double counting and therefore conservatism in the outputs and conclusions. For both northern gannet and black-legged kittiwake, the magnitude of impact was determined to be negligible, with the impact considered to not result in a discernible increase in baseline mortality rate due to the small numbers of estimated mortalities. As such, the effect on both species was determined to be minor adverse, and therefore not significant in EIA terms.

4.5.1.2 Effects of the Proposed Variation

249. Due to changes in some of the WTG parameters being proposed in the varied design envelope, additional CRM was undertaken to quantify the potential change in collision risk levels in comparison to the previously assessed collision risk in the 2023 EIAR (GVOWL, 2023a). As detailed within **Appendix B**, for both varied worst case design scenarios modelled (Scenario 1: 35 x 14 MW WTGs (with power boost option to 15 MW) and Scenario 2: 30 x 18.5 MW WTGs), impacts were less than predicted for the consented worst-case design for all four seabirds, though not to a level which would materially alter the effect significance. Based on the model predictions presented in **Appendix B**, it can confidently be concluded that the Proposed Variation does not materially alter the magnitude of the impact, or the residual effect identified in the original assessment (GVOWL, 2023a) and the Supplementary Ornithological Assessment Report (GVOWL, 2023d).

250. In the case of combined collision risk and displacement, given there is no change to the red line boundary for the Windfarm Site, the Proposed Variation does not materially alter the magnitude of the impact, or the residual effect identified in the original assessment (GVOWL, 2023a) and the Supplementary Ornithological Assessment Report (GVOWL, 2023d).

4.5.1.3 Conclusion and EIA Screening Outcome

251. In accordance with the Schedule 3 criteria of the EIA Regulations the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall nature and scale. The location of the development is unchanged, and the receiving environment, while used by a range of bird species, is not considered to be of elevated or unique sensitivity in relation to this impact pathway. The changes in WTG parameters within the Proposed Variation are predicted to reduce the potential collision risk to seabirds compared to the consented design. While Scenario 2 includes an increase in maximum rotor radius (130 m), this is offset by a reduced maximum number of WTGs (30 x 18.5 MW WTGs). In contrast, Scenario 1 retains the consented maximum of 35 WTGs but with a smaller maximum rotor radius (118 m vs 121 m (consented)). As such, updated CRM indicates a reduction in collision risk under both scenarios relative to the consented design.

252. There is no material change to the magnitude of the impact or the residual effect of this impact pathway as a result of the Proposed Variation. This impact pathway is therefore screened out of further EIA.

4.6 Shipping and Navigation

253. Following the initial screening process presented in **Section 3** and **Appendix A**, the impact pathways listed in **Table 4.27** have been brought forward for detailed evaluation. For each impact pathway, the table presents a comparison of the WCS parameters defined in **Chapter 14: Shipping and Navigation** of the 2023 EIAR (GVOWL, 2023a) with those relevant to the Proposed Variation. As outlined in **Section 1.4.3**, the WCS parameters reflect both the Windfarm Site infrastructure and the OECs, where relevant, which is consistent with the approach adopted in the 2023 EIAR (GVOWL, 2023a). As the Proposed Variation relates only to infrastructure within the Windfarm Site and no changes are proposed to the OECs, the WCS parameters for the OECs remain unchanged. No new impact pathways for this topic have been identified because of the Proposed Variation.

Table 4.27 Summary of the screened in shipping and navigation impact pathways and associated worst-case scenarios

Impact Pathway	Consented Worst-Case Scenario	Varied Worst-Case Scenario	Comments
O6: Reduction of under keel clearance	**Windfarm Site Key Parameters:** • Full build out of Windfarm Site; • Up to 35 WTGs; • Barge substructures; • Up to six mooring lines; • Mooring line angle of descent of 14° from horizontal; • Up to 72 nm of IACs; • Burial of cables to between 0.6 and 1.5 m where feasible, external protection used where target depths cannot be met; and • Operational life of 35 years. **OECs Key Parameters:** • Up to four OECs with total length 149 nm; • Burial of OECs to between 0.6 and 1.5 m where feasible, external protection used where target depths cannot be met; • Up to 3 km of OECs[§§§§] requiring external protection, with a height of up to 1.5 m; and • Operational life of 35 years.	**Windfarm Site Key Parameters:** • Full build out of Windfarm Site; • Up to 35 WTGs; • Barge substructures; • Up to nine mooring lines; • Mooring line angle of descent of 6.4° (taut mooring system) from horizontal; • Up to 72 nm of IACs; • Burial of cables to between 0.6 and 3.0 m (average 1.5 m) where feasible, external protection used where target depths cannot be met; and • Operational life of 35 years. **OECs Key Parameters:** • Up to four OECs with total length 149 nm; • Burial of OECs to between 0.6 and 1.5 m where feasible, external protection used where target depths cannot be met; • Up to 3 km of OECs requiring external protection, with a height of up to 1.5 m; and • Operational life of 35 years.	The varied design envelope increases the number of mooring lines per WTG from six to nine, resulting in an increase from 210 to 315 total mooring lines across the Windfarm Site. Additionally, the mooring line angle of descent is shallower, changing from 14° to 6.4°, meaning a greater portion of each mooring line remains closer to the water surface for longer distances.

[§§§§] This applies to sections of the OEC route to landfall where burial may not be achievable. While external protection may also be required along the OEC to the Buzzard oil and gas platform and for the IACs within the Windfarm Site, these areas lie in deep water and are not relevant to the under-keel clearance impact pathway. As such, they are not included in the WCS.

4.6.1 O6: Reduction of Under Keel Clearance

4.6.1.1 Existing Assessment of Effects of the Consented Project

254. **Chapter 14: Shipping and Navigation** of the 2023 EIAR (GVOWL, 2023a) concluded that the significance of risk for the reduction of under keel clearance was **tolerable with mitigation** and therefore **not significant** in EIA terms. This assumed additional mitigation; confirmation of available under keel clearance in agreement with MCA and NLB post installation, and the implementation of ensuring plotter overlays are made available to fishing vessels including via Fisheries Liaison Officer (FLO) liaison.

255. These conclusions were based on analysis in the Navigation Risk Assessment (NRA) undertaken in support of **Chapter 14: Shipping and Navigation** which showed that the that commercial vessels would be unlikely to pass in close proximity to the floating substructures and hence be at risk of subsea interaction.

256. Therefore, it is likely that any vessels in proximity to the substructures will be small (e.g., fishing, recreational), noting that such vessels will typically have smaller draughts than larger commercial vessels. An assessment of fishing vessel draughts relative to the predicted mooring line descents was undertaken as part of the NRA, which showed that a typical fishing vessel in the area would have approximately 5 m clearance assuming it remained in excess of 20 m from the worst-case substructure and mooring line configuration in the original envelope (the SSB). This increased to 25 m assuming the maximum fishing vessel draught recorded within the data. It was considered likely that any vessels passing in that close a proximity to the substructures will be transiting with caution noting that the surface section of the mooring lines will be visible above the waterline, and the relevant infrastructure will be charted.

4.6.1.2 Effects of the Proposed Variation

257. The key parameter change in terms of under keel clearance is the reduction in angle of descent of the taut mooring system from 14° to 6.4°. This reduction means that the taut mooring line system will be closer to the surface, and hence there may be an increased risk of under keel interaction to vessels within the Windfarm Site.

258. Due to the proposed change, additional evaluation has been undertaken to determine the potential change in risk levels associated with the reduction in under keel clearance as a result of the mooring lines.

259. The deepest draught associated with a fishing vessel recorded within the shipping and navigation study area over the course of three years was 8.6 m. In the original assessment, it was determined that such a vessel would have at least 5 m of clearance assuming it stayed in excess of 25 m from a SSB and 15 m from a semisubmersible structure. The evaluation undertaken based on the Proposed Variation indicates that the vessel would have at least 5 m of clearance assuming it stayed in excess of 12 m from a catenary mooring line and 33 m from a taut mooring line. Therefore, in order to ensure a clearance of at least 5 m and assuming a worst-case mooring system, the minimum distance to the structure for such a vessel increases from 25 m to 33 m under the Proposed Variation.

260. It is noted that an additional dynamic cable configuration has also been added to the Proposed Variation. It is anticipated that the new configuration (a "tethered wave" option) would provide a more stable catenary meaning that the motion including the clearance of the hog bend with the surface will be more controlled and will be reduced from that exhibited in the lazy wave configurations previously included. This means the dynamic cables are likely to be further from the surface in all conditions.

4.6.1.3 Conclusion and EIA Screening Outcome

261. In accordance with the Schedule 3 criteria of the EIA Regulations the characteristics of the development remain consistent with those assessed in the 2023 EIAR (GVOWL, 2023a), with the varied design envelope still representing a floating offshore windfarm of the same overall nature and scale. The location of the development is unchanged, and the receiving environment, while used by a range of vessels, is not considered to be of elevated or unique sensitivity in relation to this impact pathway. The characteristics of the impact pathway, including its spatially constrained nature, remain comparable to those previously assessed.

262. The updated evaluation determines that fishing vessels would be required to pass slightly further from a structure to ensure a minimum clearance of 5 m, but this difference in distance is not considered material especially given that fishing vessels would be unlikely to pass a structure at this proximity.

263. Therefore there is considered to be no material change to the significance of impact for the reduction of under keel clearance as a result of the Proposed Variation, assuming the identified additional mitigation remains in place (confirmation of available under keel clearance in agreement with MCA and NLB post installation, and the implementation of ensuring plotter overlays are made available to fishing vessels including via FLO liaison). This impact is therefore screened out of further EIA.

4.7 Cumulative Effect Evaluation

264. Following a detailed evaluation of potential environmental impacts and effects presented in **Sections 4.1** to **4.6**, it is confirmed that the Proposed Variation does not introduce any new, previously unassessed impact pathways, nor does it materially change the magnitude, nature, or significance of the impacts and residual effects originally assessed in the 2023 EIAR (GVOWL, 2023a). Consequently, the Project's contribution to cumulative effects with other consented and proposed projects is not materially different from that presented in the 2023 EIAR (GVOWL, 2023a).

265. It is acknowledged that additional projects have been consented or come forward since the submission of the 2023 EIAR (GVOWL, 2023a). However, as the Proposed Variation does not materially alter the Project's individual effects or its contribution to any cumulative effects, no further cumulative effects assessment is necessary or proportionate. Since submission of the 2023 EIAR (GVOWL, 2023a), other projects consented or submitted in the region will have included the Project in their cumulative effects assessments based on the originally consented design envelope. As the Proposed Variation does not materially alter the conclusions of the 2023 EIAR, it does not materially affect the conclusions of those projects' cumulative effects assessments, which remain valid.

4.8 Habitats Regulations Appraisal

266. A full HRA was undertaken by MD-LOT (MD-LOT, 2024), as the competent authority, to inform the determination of the Project s.36 Consent (Scottish Ministers, 2024a) and associated Marine Licences (Scottish Ministers, 2024b, 2024c, and 2024d). This appraisal was supported by a HRA Screening Report (GVOWL, 2023b), a Report to Inform Appropriate Assessment (GVOWL, 2023c), and a Supplementary Ornithological Assessment Report (GVOWL, 2023d), which assessed the potential for LSE and, where relevant, AEOSI on relevant European Sites via impact pathways associated with benthic ecology, fish and shellfish ecology, marine mammals, and offshore ornithology.

267. The HRA concluded that no AEOSI would occur for the majority of European Sites, either alone or in-combination. However, MD-LOT identified that AEOSI could not be ruled out for several Special Protection Areas (SPA) designated for seabird features, in relation to in-combination effects. As a result, appropriate compensatory measures were secured in accordance with Regulation 49 of the Conservation (Natural Habitats &c.) Regulations 1994 and Regulation 29 of the Conservation of Offshore Marine Habitats and Species Regulations 2017. These measures were secured through conditions attached to the s.36 Consent (Scottish Ministers, 2024a) and Marine Licences (Scottish Ministers, 2024b, 2024c, and 2024d).

268. The SPAs for which in-combination AEOSI could not be excluded were:

- Buchan Ness to Collieston Coast SPA: Black-legged kittiwake;
- Fowlsheugh SPA: Common guillemot and black-legged kittiwake;
- Troup, Pennan and Lion's Head SPA: Black-legged kittiwake;
- East Caithness Cliffs SPA: Razorbill, black-legged kittiwake, and common guillemot; and
- Forth Islands SPA: Northern gannet and Atlantic puffin (*Fratercula arctica*).

269. The HRA screening for the Proposed Variation has been undertaken in accordance with the Habitats Regulations. The purpose of the screening exercise is to consider whether the Proposed Variation introduces any new or materially different potential for LSE on European Sites, either alone or in-combination, beyond what was previously assessed and concluded in the original HRA (MD-LOT, 2024). The screening exercise does not re-open the assessment of the Project as a whole or reconsider the conclusions of AEOSI unless new or materially different LSE is identified.

270. As set out in Section 3 (Appendix A) and Section 4 of this Screening Report, the Proposed Variation does not introduce any new impact pathways, or materially alter the magnitude, nature, or spatial/temporal extent of previously assessed pathways. For example, for seabird features such as common guillemot, razorbill, and Atlantic puffin, the relevant impact pathway is displacement from the physical presence of infrastructure. As the Windfarm Site boundary and the maximum number of WTGs remain unchanged, the spatial extent and scale of potential displacement is unaffected. For black-legged kittiwake and northern gannet, the relevant impact pathway is a combination of displacement and collision risk. Displacement remains unchanged for the reasons detailed above, and whilst the Proposed Variation introduces minor changes to WTG design, updated CRM (Appendix B) shows that predicted collision mortality is marginally reduced.

271. As such, the Proposed Variation does not give rise to any new or materially different potential for LSE on any European Site, either alone or in-combination. On this basis, the conclusions of the original HRA (MD-LOT, 2024) remain valid and no further assessment is required, or considered proportionate, under the Habitats Regulations.

5 Conclusion and EIA Screening Outcome

272. A comprehensive review of the consented and the varied design envelopes has been undertaken to identify the changes introduced through this Proposed Variation, this included evaluation of the relevant project design envelope parameters of the 2023 EIAR (GVOWL, 2023a) and identification of those subject to change. Each environmental topic, and associated impact pathways, assessed in the 2023 EIAR (GVOWL, 2023a) was then reviewed (**Section 3** and **Appendix A**) with impact pathways initially screened out where the Proposed Variation was not considered to have the potential to materially alter residual effects, as originally assessed. The potential for the Proposed Variation to give rise to new impact pathways was also considered at this stage, it was concluded that the Proposed Variation did not introduce new, previously unassessed impact pathways. Impact pathways with potential for a material change, as a result of the Proposed Variation, were brought forward for detailed evaluation in **Section 4**.

273. This detailed evaluation process determined that none of the impact pathways would result in a material change to the residual effects of the Project as previously assessed. Consequentially, no material change to cumulative effects was identified.

274. The conclusions of the HRA undertaken for the consented Project remain valid. The Proposed Variation does not materially affect the conclusions of AEOSI and does not alter the requirement for, or the delivery of, the agreed seabird compensatory measures. Rather, the updated modelling (**Appendix B**) suggests that the refinements in project design covered in this Screening Report present a reduced risk to seabirds than that set out in the original assessments. Seabird compensation measures remain secure and enforceable through consent conditions.

275. In line with the EIA Regulations, and in regard to the Schedule 3 screening criteria, it is concluded that the Proposed Variation does not materially alter the characteristics of the Project, its location, or the characteristics of the potential impact (**Section 3** and **Section 4**) when compared to the consented Project. The Proposed Variation does not give rise to any new or materially different likely environmental effects (significant or otherwise) when compared to those previously assessed and as such the Proposed Variation does not give rise to any significant effects on the environment. An EIA is therefore **not required** for the Proposed Variation under the relevant EIA Regulations.

276. The Project is a key component of the Innovation and Targeted Oil and Gas leasing round, supporting Scotland's and the UK's net zero objectives. The Proposed Variation maintains the Project's role in enabling the decarbonisation of O&G infrastructure and supporting a just transition to a low-carbon economy.

277. Securing consent for the Proposed Variation will facilitate optimisation of the Project design in response to current market availability of technologies, and supply chain considerations. The varied design envelope reflects the most up-to-date understanding of design development and infrastructure configurations and will enable the Project to proceed efficiently and maximise its intended carbon reduction benefits in alignment with national energy policy objectives.

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A Appendix – Environmental Impact Assessment Review

278. All impact pathways assessed in the 2023 EIAR (GVOWL, 2023a) have been re-evaluated in the context of the Proposed Variation. **Table A.5.1** presents a topic-by-topic review of potential environmental impacts, considering whether the Proposed Variation introduces any new or materially different impact pathways, or alters the magnitude, nature, or significance of effects previously assessed.

279. For topics screened out of further detailed evaluation (e.g., aviation and radar), the potential for cumulative effects has also been reviewed in the context of the Proposed Variation. **Chapter 20: Transboundary and Cumulative Impacts** of the EIAR (GVOWL, 2023a) set out the topics for which cumulative effects were assessed, the relevant impact pathways considered, and a list of other plans and projects that were considered. Although additional developments have been consented and brought forward into the public domain since the submission of the 2023 EIAR (GVOWL, 2023a), none are sufficiently close enough to the Project, or of a type or scale, that would materially alter the cumulative baseline or the conclusions of the original cumulative effects assessment for these screened out topics (including aviation and radar). Furthermore, the key consideration for this screening exercise is whether the Proposed Variation would result in a material change to the Project's own contribution to any cumulative effect. As the Proposed Variation does not introduce any new or materially different individual effects for these topics it is determined that the Project's contribution to cumulative effects for all topics screened out of detailed evaluation in **Table A.5.1** is not materially different to that concluded in the 2023 EIAR (GVOWL, 2023a), and no further cumulative assessment is considered necessary or proportionate.

280. Impact pathways associated with the decommissioning phase were identified and considered in the 2023 EIAR (GVOWL, 2023a) and were assessed to be broadly comparable in type, magnitude, and spatial/temporal extent to those associated with the construction phase. No significant decommissioning effects were identified. As the Proposed Variation does not introduce any new, previously unassessed impact pathways, nor does it materially alter the magnitude, nature or significance of residual effects identified for the construction phase, in relation to the impact pathways screened out through the initial screening process (**Table A.5.1**), it is also concluded that the residual effects associated with decommissioning are likewise not materially different to those previously assessed. Therefore, in line with the principle of proportionality, decommissioning impact pathways are not listed separately in the screening table and are adequately represented under the construction phase impact pathways.

281. A summary of the outcome of this initial screening process is presented in **Section 3**. Where a topic or impact is screened in for further evaluation, this further evaluation is presented in **Section 4**, including further consideration of potential cumulative effects for these topics where applicable.

Table A.5.1 Assessment of the Proposed Variation's implications on the conclusions of the 2023 EIAR (GVOWL, 2023a)

<table>
<tr><th>Receptor Topic</th><th>Impacts Assessed in the 2023 EIAR</th><th>Residual Effect Predicted in 2023 EIAR</th><th>Implication of the Proposed Variation</th><th>Further Evaluation Required within this Screening Report (Section 4)</th><th>Screening Rationale</th></tr>
<tr><td rowspan="7">Marine Geology and Physical Processes (Evaluated further in Section 4)</td><td>C1: Damage to seabed structure and form</td><td rowspan="7">Negligible adverse – not significant</td><td rowspan="7">WTGs:
The proposed changes to the WTGs are not relevant to this receptor group, as they do not affect the seabed.

Floating Substructures and Mooring System:
The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the originally assessed effects.

IACs:
The proposed changes to the IAC system are relevant to this receptor group and could potentially materially alter the originally assessed effects.

OSP:
The proposed changes to the OSP foundation are relevant to this receptor group and could potentially materially alter the originally assessed effects.</td><td>No</td><td>The Marine Geology and Physical Processes chapter (GVOWL, 2023a) states that the receptor is the seabed (seaward of Horizontal Directional Drilling (HDD) option exit point to 12 nm limit). The Proposed Variation relates to the Windfarm Site only.</td></tr>
<tr><td>C2: Increase in suspended sediment concentration</td><td>No</td><td>The Marine Geology and Physical Processes chapter (GVOWL, 2023a) states that the receptor is the seabed (seaward of HDD option exit point to 12 nm limit). The Proposed Variation relates to the Windfarm Site only.</td></tr>
<tr><td>C3: Disturbance of seabed sediments during cable installation</td><td>Yes</td><td>The Proposed Variation increases the worst-case scenario for this impact pathway in relation to IAC installation activities within the Windfarm Site. Further evaluation required in Section 4.1.</td></tr>
<tr><td>O1: Rock deposits or concrete mattresses footprint on seabed</td><td>No</td><td>The Marine Geology and Physical Processes chapter (GVOWL, 2023a) states that the receptor is the seabed (seaward of HDD option exit point to 12 nm limit). The Proposed Variation relates to the Windfarm Site only.</td></tr>
<tr><td>O2: Effect of rock deposits or concrete mattresses on tide, wave and sediment regime</td><td>No</td><td>The Marine Geology and Physical Processes chapter (GVOWL, 2023a) states that the receptor is the seabed (seaward of HDD option exit point to 12 nm limit). The Proposed Variation relates to the Windfarm Site only.</td></tr>
<tr><td>O3: Disturbance of seabed sediments due to catenary action of mooring lines in Windfarm Site</td><td>Yes</td><td>The Proposed Variation increases the worst-case scenario for this impact pathway. Further evaluation required in Section 4.1.</td></tr>
<tr><td>O4: Disturbance of seabed sediments due to scour around the foundations of the mooring anchors in Windfarm Site</td><td>No</td><td>The original assessment (GVOWL, 2023a) concluded that scour is likely to be minimal given the deep waters within the Windfarm Site. As such, the Proposed Variation is unlikely to result in a material change to this impact pathway. Therefore, this impact pathway is screened out of further evaluation.</td></tr>
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Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O5: Changes to water column mixing by the presence of structures and/or alterations to the near-surface wind speeds in Windfarm Site			No	The original assessment (GVOWL, 2023a) concluded that the Project would have no effect on the regional-scale patterns of seasonal stratification.
Marine Sediment and Water Quality (Screened out)	C1: Increase in suspended sediment concentrations created by installation of turbine substructures, inter-array cables and OSP foundations	Negligible to minor adverse – not significant	WTGs: The proposed changes to the WTGs are not relevant to this receptor group, as they do not affect the seabed. Floating Substructures and Mooring System: The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the originally assessed effects. IACs: The proposed changes to the IAC system are relevant to this receptor group and could potentially materially alter the originally assessed effects. OSP: The proposed changes to the OSP foundation are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	The nature, scale, and extent of sediment disturbance from the installation of the floating substructures, IACs, and OSP foundation remain consistent with those assessed in the 2023 EIAR. Sediment disturbance is localised, affecting mainly sandy sediments that rapidly resettle, and is limited by site-specific water depths and hydrodynamic conditions, previous site-specific surveys confirm this. The Construction Environmental Management Plan (CEMP) will continue to provide effective mitigation to minimise increases in suspended sediment concentrations. Therefore, no material change to the predicted effect is expected, and this impact pathway is screened out.
	C2: Increase in suspended sediment concentration associated with export cable installation			No	The Proposed Variation is not seeking to amend any parameters associated with the OEC system. Therefore, no material change to the predicted effect is expected, and this impact pathway is screened out.
	C3: Increase in suspended solids concentrations due to works at landfall			No	The Proposed Variation is not seeking to amend any parameters associated with landfall works. Therefore, no material change to the predicted effect is expected, and this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	C4: Deterioration in water quality due to re-suspension of sediment bound contaminants offshore			No	The proposed layout will deliberately avoid placing turbines and substructures directly above abandoned well-centres, which are the areas with the highest potential for seabed contamination. Site-specific sediment chemistry surveys confirm contaminant levels are generally within natural background ranges, with only localised elevated concentrations near one well. Sediment resuspension during construction is predicted to be low due to limited seabed disturbance and the predominance of sandy sediments. The CEMP will continue to implement best practice mitigation to minimise sediment disturbance and contaminant mobilisation. Therefore, no material change to the original assessment is predicted, and this impact pathway is screened out.
	C5: Deterioration in water quality due to re-suspension of sediment bound contaminants along the export cable corridor			No	The Proposed Variation is not seeking to amend any parameters associated with the OEC system. Therefore, no material change to the predicted effect is expected, and this impact pathway is screened out.
	O1: Increase in suspended sediment concentrations due to mooring lines and erosion/ scour offshore			No	The nature, scale, and extent of sediment disturbance from mooring line movement and anchor scour remain consistent with those originally assessed. Sediment disturbance is localised, affecting mainly sandy sediments that rapidly resettle, and is limited by site-specific water depths and current conditions, previous site-specific surveys confirm this. While minor changes to the magnitude may occur, these are not expected to materially alter the impact compared to the original assessment. Therefore, this impact pathway is screened out.
	O2: Alteration of water column mixing associated from physical presence of windfarm structures and changes to surface wind speeds			No	The original assessment (GVOWL, 2023a) concluded that the Project would have no effect on the regional-scale patterns of seasonal stratification.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O3: Increase in suspended sediment concentrations due to cable repairs/reburial			No	Suspended sediment concentrations resulting from maintenance activities, such as cable repair/replacement, are expected to be limited in both spatial extent and duration. These activities are infrequent and localised, with disturbance areas substantially smaller than those associated with cable installation during construction. The Proposed Variation does not materially change the nature or scale of these activities and therefore does not materially change the effect assessed in the original assessment. This impact pathway is screened out.
Benthic Ecology (Evaluated further in Section 4)	C1: Physical disturbance and temporary habitat loss of seabed habitat	Minor adverse – not significant	<u>WTGs:</u> The proposed changes to the WTGs are not relevant to this receptor group, as they do not affect the seabed. <u>Floating Substructures and Mooring System:</u> The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the originally assessed effects. <u>IACs:</u> The proposed changes to the IAC system are relevant to this receptor group and could potentially materially alter the originally assessed effects.	Yes	The Proposed Variation includes changes to the mooring system and IACs that may alter the extent and distribution of seabed disturbance. These changes have the potential to increase or shift the footprint of temporary seabed habitat loss compared to what was assessed in the 2023 EIAR. Given the potential for a material change in the overall magnitude of this impact pathway further evaluation is required in **Section 4.2**.
	C2: Increased suspended sediments and sediment re-deposition			No	The nature, scale, and extent of sediment disturbance from the installation of the floating substructures, IACs, and OSP foundation remain consistent with those assessed in the 2023 EIAR. Sediment disturbance is localised, affecting mainly sandy sediments that rapidly resettle, and is limited by site-specific water depths and hydrodynamic conditions, previous site-specific surveys confirm this. The CEMP will continue to provide effective mitigation to minimise increases in suspended sediment concentrations. Therefore, no material change to the predicted effect is expected, and this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	C3: Potential re-mobilisation of contaminated sediment during intrusive works		OSP: The proposed changes to the OSP foundation are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	Sediment chemistry data indicate that background contaminant levels across the site are generally within typical North Sea ranges. The proposed layout will avoid abandoned well sites, which represent areas with the highest potential for localised contamination. Intrusive, sediment suspending activities will be managed under the CEMP, which will minimise sediment resuspension and therefore reduce the overall magnitude of the impact. Additionally, low near-bed water velocities reduce the potential for widespread dispersion. The Proposed Variation does not materially change the nature or extent of this impact compared to the original assessment. This impact pathway is screened out.
	C4: Potential impacts on the Southern Trench MPA			No	The Proposed Variation is not seeking to amend any parameters associated with the OEC system. Therefore, no material change to the predicted effect is expected, and this impact pathway is screened out.
	C5: Potential introduction of Marine Invasive Non-Native Species (MINNS)			No	The nature and scale of construction activities relevant to the potential introduction of MINNS remain consistent with those originally assessed in the 2023 EIAR (GVOWL, 2023a). A robust CEMP will continue to mitigate the risk of MINNS introduction from ballast water and biofouling. The Proposed Variation does not materially change the potential for MINNS introduction. This impact pathway is screened out.
	O1: Permanent habitat loss and introduction of hard substrate			Yes	The Proposed Variation seeks to make amendments to some project infrastructure that will be in direct contact with the seabed, which could result in material change to the level of permanent habitat loss and introduction of hard substrate. This impact pathway is therefore screened in for further evaluation in **Section 4.2**.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O2: Impacts of scour on benthic communities arising from the mooring chains and anchors			No	The original assessment (GVOWL, 2023a) concluded that scour is likely to be minimal given the deep waters within the Windfarm Site. As such, the Proposed Variation is unlikely to result in a material change to this impact pathway. Therefore, this impact pathway is screened out of further evaluation.
	O3: Electromagnetic Fields (EMF)			No	The nature of the impact from EMFs remains consistent with that assessed in the 2023 EIAR (GVOWL, 2023a). There will continue to be sections of dynamic and static IACs within the Windfarm Site and EMF emissions will continue to be of low magnitude, highly localised and attenuate rapidly with distance. Cables will remain armoured and static IAC sections will be buried to an average burial depth of 1.5 m (minimum burial depth of 0.6 m and a maximum burial depth of 3 m). The Proposed Variation would not materially alter the overall magnitude of the impact, and the effect would not be materially different to that previously assessed. This impact pathway is therefore screened out.
	O4: Potential introduction of MINNS			No	The Proposed Variation does not materially alter the overall magnitude of this impact pathway. Embedded mitigation measures will remain in place, including the implementation of biosecurity plans aligned with best practice, contractor training to identify and respond to MINNS and the development of a management and monitoring plan should MINNS be detected on-site. These measures will continue to reduce the likelihood of MINNS introduction and spread. As such, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
Fish and Shellfish Ecology (Evaluated further in Section 4)	C1: Physical disturbance and temporary habitat loss	Negligible to minor adverse – not significant	WTGs: The proposed changes to the WTGs are not relevant to this receptor group, as they do not affect the seabed. Floating Substructures and Mooring System: The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the originally assessed effects. IACs: The proposed changes to the IAC system are relevant to this receptor group and could potentially materially alter the originally assessed effects. OSP: The proposed changes to the OSP foundation and associated noise from piling works are relevant to this receptor group and could potentially materially alter the originally assessed effects.	Yes	The Proposed Variation includes changes to the mooring system and IACs that may alter the extent and distribution of seabed disturbance. These changes have the potential to increase or shift the footprint of temporary seabed habitat loss compared to what was assessed in the 2023 EIAR. Given the potential for a material change in the overall magnitude of this impact pathway further evaluation is required in **Section 4.3**.
	C2: Increased suspended sediments and sediment re-deposition			No	The nature, scale, and extent of sediment disturbance from the installation of the floating substructures, IACs, and OSP foundation remain consistent with those assessed in the 2023 EIAR. Sediment disturbance is localised, affecting mainly sandy sediments that rapidly resettle, and is limited by site-specific water depths and hydrodynamic conditions, previous site-specific surveys confirm this. The CEMP will continue to provide effective mitigation to minimise increases in suspended sediment concentrations. Therefore, no material change to the predicted effect is expected, and this impact pathway is screened out.
	C3: Re-mobilisation of contaminated sediments and sediment redistribution			No	Sediment chemistry data indicate that background contaminant levels across the site are generally within typical North Sea ranges. The proposed layout will avoid abandoned well sites, which represent areas with the highest potential for localised contamination. Intrusive, sediment suspending activities, will be managed under the CEMP, which will minimise sediment resuspension and therefore reduce the overall magnitude of the impact. Additionally, low near-bed water velocities reduce the potential for widespread dispersion. The Proposed Variation does not materially change the nature or extent of this impact compared to the original assessment. This impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	C4: Underwater noise and vibration			Yes	The Proposed Variation includes changes to piling parameters for the OSP, including an increase in maximum hammer strength energy and the maximum number of piles. These changes have the potential to alter the predicted underwater noise (UWN) levels and associated impact ranges. As underwater water is a key pressure for fish and shellfish receptors, and the overall magnitude of this pressure may be materially different to that assessed in the 2023 EIAR (GVOWL, 2023a), this impact pathway is screened in for further evaluation in **Section 4.3**.
	O1: Temporary and permanent habitat loss			Yes	The Proposed Variation seeks to make amendments to some project infrastructure that will be in direct contact with the seabed, which could result in material change to the level of permanent habitat loss and introduction of hard substrate. This impact pathway is therefore screened in for further evaluation in **Section 4.3**.
	O2: Re-mobilisation of contaminated sediments and sediment redistribution			No	This impact pathway was considered in the 2023 EIAR (GVOWL, 2023a) in relation to the repair and replacement of OECs along the Offshore Export Cable Corridors. As the Proposed Variation does not relate to OECs, and construction impact pathway C3 has already addressed the potential for remobilisation of contaminated sediments and sediment redistribution, no material change to the originally assessed effect is anticipated. Therefore, this impact pathway is screened out.
	O3: Introduction foundations, scour protection, hard substrate and habitats			No	The original assessment (GVOWL, 2023a) concluded that scour is likely to be minimal given the deep waters within the Windfarm Site. As such, the Proposed Variation is unlikely to result in a material change to this impact pathway. Therefore, this impact pathway is screened out of further evaluation.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O4: Underwater noise and vibration			No	Operational UWN and vibration are significantly lower than the levels generated during construction piling activities. Floating substructures and mooring systems incorporate dampening, unlike rigidly coupled fixed foundations (i.e., monopiles), which help to reduce operational noise transmission. These characteristics remain consistent between the original design envelope and the Proposed Variation. As such, the Proposed Variation does not materially change the effect as originally assessed, this impact pathway is screened out.
	O5: EMFs			No	The nature of the impact from EMFs remains consistent with that assessed in the 2023 EIAR (GVOWL, 2023a). There will continue to be sections of dynamic and static IACs within the Windfarm Site and EMF emissions will continue to be of negligible to low magnitude, highly localised and attenuate rapidly with distance. Cables will remain armoured and static IAC sections will be buried to an average burial depth of 1.5 m (minimum burial depth of 0.6 m and a maximum burial depth of 3 m) or protected by concrete mattresses. The Proposed Variation would not materially alter the overall magnitude of the impact, and the effect would not be materially different to that previously assessed. This impact pathway is therefore screened out.
	O6: Commercially exploited species associated with their displacement from the area of activity/works				The total area of the Windfarm Site remains unchanged under the Proposed Variation, covering 116 km^2, consistent with the originally consented Project. This spatial extent is small in the context of the distributional ranges of commercially exploited fish and shellfish species in the wider North Sea. As such, no material difference in the overall magnitude of impact is predicted. An effect assessment of negligible beneficial – minor beneficial therefore remains consistent with that assessed in the 2023 EIAR (GVOWL, 2023a). This impact pathway is therefore screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
Marine Mammal Ecology (Evaluated further in Section 4)	C1: Auditory Injury and Disturbance from underwater noise during geophysical surveys	Negligible to minor adverse – not significant	WTGs: The proposed changes to the WTGs are not relevant to this receptor group. Floating Substructures and Mooring System: The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the originally assessed effects. IACs: The proposed changes to the IAC system are relevant to this receptor group and could potentially materially alter the originally assessed effects. OSP: The proposed changes to the OSP foundation, particularly amendments to the piling parameters, are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	The Proposed Variation does not include any changes to the geophysical survey activities as previously assessed. Therefore, there is no change to the overall magnitude of this impact pathway. The conclusions of the of the original assessment remain valid, and no material change to the effect is anticipated. Therefore, this impact pathway is screened out.
	C2: Physical injury, auditory injury and disturbance impacts resulting from the underwater noise associated with clearance of UXO			No	The Proposed Variation does not involve any changes to the UXO clearance scope or requirements assessed in the 2023 EIAR (GVOWL, 2023a). The nature and scale of potential UXO related activities remains consistent to that described in the 2023 EIAR. As such, the overall magnitude of the impact is not materially different from that originally assessed. In addition, embedded mitigation, including the adherence to the Marine Mammal Mitigation Protocol (MMMP) for UXO clearance, will remain in place. Therefore, this impact pathway is screened out.
	C3: Auditory injury and disturbance resulting from underwater noise during piling, including ADD activation			Yes	The Proposed Variation includes changes to piling parameters, including increased maximum hammer strength energy and maximum number of piles for the OSP jacket foundation. These changes could materially alter UWN levels compared to the original assessment (GVOWL, 2023a). This impact pathway is therefore screened in for further evaluation in **Section 4.4**.
	C4: Disturbance impacts resulting from underwater noise during other construction activities, such as cable installation and turbine mooring installation			No	The nature and scale of this impact pathway remains consistent with those assessed in the 2023 EIAR (GVOWL, 2023a). No material change in UWN levels or the resulting disturbance impact is expected. Therefore, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	C5 and C6: Underwater noise, disturbance and interaction from construction vessels			No	The nature and scale of construction activities remain consistent with the original assessment. No material change in the overall magnitude of the impact is anticipated. Embedded mitigation, including adherence to the Scottish Marine Wildlife Watching Code (SMWWC) and implementation of best practice through the CEMP, will continue to be applied. Therefore, this impact pathway is screened out.
	C7: Barrier effects as a result of underwater noise			Yes	The Proposed Variation includes changes to piling parameters, including an increased maximum hammer energy and maximum number of piles required for the OSP jacket foundation. These may alter the duration or spatial extent of UWN, potentially increasing the likelihood or severity of behavioural avoidance and barrier effects. As such, this impact pathway is screened in for further evaluation in **Section 4.4**.
	C8: Changes to prey resource			No	The nature and scale of activities relevant to prey availability remain consistent with the 2023 EIAR. The Proposed Variation does not materially alter pressures affecting prey species. This pathway has been informed by the detailed evaluations in **Sections 4.2** (Benthic Ecology) and **4.3** (Fish and Shellfish Ecology), which concluded that the Proposed Variation does not introduce any new or materially different residual effects. As such, the Project's contribution to this impact remains as previously assessed and this impact pathway is screened out.
	O1: Underwater noise from operational turbines causing disturbance			No	Although the Proposed Variation involves an increase in the maximum capacity of turbine that could be used, the number and type of WTGs remain consistent with the original assessment. Floating WTGs are associated with lower operational noise emissions compared to fixed foundation WTGs, and no material change to the overall magnitude of the impact and subsequent residual effect, as determined in the original assessment, is anticipated. Therefore, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O2: Underwater noise from maintenance activities and vessels causing disturbance			No	The nature and scale of operational activities remain consistent with the original assessment. No material change in the overall magnitude of the impact is anticipated. Therefore, this impact pathway is screened out.
	O3: Barrier effect from underwater noise			No	There is no material change to the effect of UWN from operational WTGs (impact pathway: O1 and O2) in comparison to that assessed in the 2023 EIAR (GVOWL, 2023a). Consequently, no material change to the potential for barrier effects arising from operational UWN is expected. Therefore, this impact pathway is screened out.
	O4: Interactions with vessels – increased collision risk			No	The nature and scale of operational activities remain consistent with the original assessment. No material change in the overall magnitude of the impact is anticipated. Embedded mitigation, including adherence to the SMWWC and implementation of best practice through the CEMP, will continue to be applied. Therefore, this impact pathway is screened out.
	O5: Potential entanglement with mooring lines			Yes	The Proposed Variation seeks to make some changes to mooring system parameters, including an increase of the maximum number of mooring lines per WTG and the maximum length of the mooring lines. These changes may increase the entanglement risk for marine mammals. While the original Project Environmental Monitoring Programme (PEMP), including the entanglement monitoring measures, remain in place, the potential change in risk warrants further evaluation. Therefore, this impact pathway is screened in for detailed evaluation in **Section 4.4**.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O6: EMF			No	The nature of the impact from EMFs remains consistent with that assessed in the 2023 EIAR (GVOWL, 2023a). There will continue to be sections of dynamic and static IACs within the Windfarm Site and EMF emissions will continue to be highly localised and attenuate rapidly with distance. Cables will remain armoured and static IAC sections will be buried to an average burial depth of 1.5 m (minimum burial depth of 0.6 m and a maximum burial depth of 3 m) or protected by concrete mattresses. The Proposed Variation would not materially alter the overall magnitude of the impact, and the effect would not be materially different to that previously assessed. This impact pathway is therefore screened out.
	O7: Barrier effects from physical presence of windfarm			No	The total Windfarm Site footprint remains unchanged at 116 km^2, with the maximum number of WTGs retained at 35. Given the consistency in spatial extent and infrastructure scale, it is determined that there is no material change to the overall magnitude of the impact pathway, there the residual effect is anticipated to remain consistent with that reported in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
	O8: Changes to prey resources			No	The nature and scale of activities relevant to prey availability remain consistent with the 2023 EIAR. The Proposed Variation does not materially alter pressures affecting prey species. This pathway has been informed by the detailed evaluation in **Section 4.3** (Fish and Shellfish Ecology), which concluded that the Proposed Variation does not introduce any new or materially different residual effects. As such, the Project's contribution to this impact remains as previously assessed and this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
Offshore and Intertidal Ornithology (Evaluated further in Section 4)	C1: Temporary disturbance and displacement: Windfarm Site	Negligible to minor adverse – not significant	WTGs: The proposed changes to the WTGs are relevant to this receptor group, as they could potentially materially alter the risk of collision to birds transiting through the Windfarm Site. Floating Substructures and Mooring System: The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the risk of entanglement. IACs: The proposed changes to the IAC system are not relevant to this receptor group due to no change in the spatial extent of the Windfarm Site or proposed timeframes for installation. OSP: The proposed changes to the OSP foundation are not relevant to this receptor group due to no associated effect pathway identified capable of effecting this receptor group.	No	The total Windfarm Site footprint remains unchanged at 116 km^2, with the maximum number of WTGs retained at 35. Given the consistency in spatial extent and infrastructure scale, it is determined that there is no material change to the overall magnitude of the impact pathway, the residual effect is anticipated to remain consistent with that reported in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
	C2: Temporary disturbance and displacement: Offshore Export Cable Corridors and Landfall			No	The extent of the Offshore Export Cable Corridors and Landfall remains unchanged. Given the consistency in spatial extent and infrastructure scale, it is determined that there is no material change to the overall magnitude of the impact pathway, the residual effect is anticipated to remain consistent with that reported in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
	C3: Indirect effects via changes in prey or habitat availability			No	The nature and scale of activities relevant to prey and habitat availability remain consistent with the 2023 EIAR (GVOWL, 2023a). The Proposed Variation does not materially alter pressures affecting prey species or habitat availability. This pathway has been informed by the detailed evaluations in **Sections 4.2** (Benthic Ecology) and **4.3** (Fish and Shellfish Ecology), which concluded that the Proposed Variation does not introduce any new or materially different residual effects. As such, the Project's contribution to this impact remains as previously assessed and this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O1: Disturbance and displacement: Windfarm Site			No	The total Windfarm Site footprint remains unchanged at 116 km^2, with the maximum number of WTGs retained at 35. Given the consistency in spatial extent and infrastructure scale, it is determined that there is no material change to the overall magnitude of the impact pathway, the residual effect is anticipated to remain consistent with that reported in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
	O2: Disturbance and displacement: Offshore Export Cable Corridors and Landfall			No	The extent of the Offshore Export Cable Corridors and Landfall remains unchanged. Given the consistency in spatial extent and infrastructure scale, it is determined that there is no material change to the overall magnitude of the impact pathway, the residual effect is anticipated to remain consistent with that reported in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
	O3: Indirect effects via changes in prey or habitat availability			No	The nature and scale of activities relevant to prey and habitat availability remain consistent with the 2023 EIAR (GVOWL, 2023a). The Proposed Variation does not materially alter pressures affecting prey species or habitat availability. This pathway has been informed by the detailed evaluations in **Sections 4.2** (Benthic Ecology) and **4.3** (Fish and Shellfish Ecology), which concluded that the Proposed Variation does not introduce any new or materially different residual effects. As such, the Project's contribution to this impact remains as previously assessed and this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O4: Entanglement with mooring lines			No	The Proposed Variation seeks to make some changes to mooring system parameters, including increases to the maximum number of mooring lines per WTG and the maximum length of the mooring lines. These changes may increase the entanglement risk for diving seabirds. However, the embedded mitigation of maintenance and entanglement monitoring measures, detailed in the PEMP, remain in place, which help to reduce the potential likelihood of any entanglement occurring. It is determined that there is no material change to the overall magnitude of the impact pathway, the residual effect is anticipated to remain consistent with that reported in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
	O5: Collision risk: Array			Yes	The Proposed Variation seeks to make several changes to WTG parameters which could materially change the potential risk of collision to birds transiting through the Windfarm Site. Therefore, this impact pathway is screened in for detailed evaluation in **Section 4.4**.
	O6: Combined operational displacement and collision risk			Yes	The Proposed Variation seeks to make several changes to WTG parameters which could materially change the potential risk of collision to birds transiting through the Windfarm Site. Therefore, this impact pathway is screened in for detailed evaluation in **Section 4.4**.
	O7: Barrier effects: Array			No	The total Windfarm Site footprint remains unchanged at 116 km^2, with the maximum number of WTGs retained at 35. Given the consistency in spatial extent and infrastructure scale, it is determined that there is no material change to the overall magnitude of the impact pathway, the residual effect is anticipated to remain consistent with that reported in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O8: Impacts on aviation and navigation lighting: Array			No	No change in navigational lighting requirements to the consented design. It is therefore determined that there is no material change to the overall magnitude of the impact pathway, the residual effect is anticipated to remain consistent with that reported in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
Commercial Fisheries (Screened out)	C1: Reduction in access to, or exclusion from established fishing grounds	Negligible to minor adverse – not significant	WTGs: The proposed changes to WTG parameters, including changes to the minimum spacing, are relevant to this receptor group and could potentially materially alter the originally assessed effects. Floating Substructures and Mooring System: The proposed changes to the floating substructures and the mooring system, including a potential for longer temporary pre-lay period for the mooring system within the Windfarm Site, are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	Embedded mitigation set out in the 2023 EIAR (GVOWL, 2023a), including the Fisheries Management and Mitigation Strategy and the appointment of a Fisheries Liaison Officer (FLO) remain in place and effective. These measures continue to facilitate communication and minimise disruption to the commercial fishing industry. The Proposed Variation does not alter the consented Windfarm Site boundary (116 km^2) or the maximum number of WTGs. Although there are some changes to the mooring system, IAC, and OSP installation parameters, these do not materially change the spatial extent or duration of temporary construction safety zones, which remain at 500 m, or the pre-construction safety zones of 50 m as previously assessed. Given the temporary nature of these restrictions, the embedded mitigation in place, and no material change to the construction footprint, the magnitude of the impact and residual effect on fishing access remain consistent with the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	C2: Displacement, leading to gear conflict and increased fishing pressure adjacent grounds		IACs: The proposed changes to the IAC system, including a potential for longer temporary pre-lay period within the Windfarm Site, are relevant to this receptor group and could potentially materially alter the originally assessed effects. OSP: The proposed changes to the OSP foundation, particularly amendments to the piling parameters, are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	The Proposed Variation does not alter the consented Windfarm Site boundary (116 km^2) or the maximum number of WTGs. Although there are some changes to the mooring system, IAC, and OSP installation parameters, these do not materially change the spatial extent or duration of temporary construction safety zones, which remain at 500 m, or the pre-construction safety zones of 50 m as previously assessed. Given the temporary nature of these restrictions, the embedded mitigation in place, and no material change to the construction footprint, the magnitude of the impact and residual effect on fishing access remain consistent with the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
	C3: Physical presence of offshore windfarm infrastructure leading to gear snagging			No	The primary risk of gear snagging during construction, such as from temporary pre-laying of moorings or IACs awaiting hook-up to substructures, burial or external protection, and accidental seabed obstructions, remain relevant. Under the Proposed Variation, the potential duration of temporary pre-laid moorings and IACs could extend up to 28 months. While this represents a longer period of potential interaction, the spatial footprint and nature of the risk remain comparable to what was assessed in the 2023 EIAR (GVOWL, 2023a). Embedded mitigation measures, including the use of safety zones (500 m during construction), guard vessels, and promulgation of information through Notice to Mariners (NtM), remain in place and effective. These measures continue to minimise the likelihood of gear snagging and facilitate awareness within the commercial fishing sector. As such, the Proposed Variation does not materially alter the magnitude of impact, or the residual effect as originally assessed, and this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	C4: Displacement or disruption of commercially important fish and shellfish resources			No	The Proposed Variation does not materially alter the predicted residual effects on fish and shellfish receptors. A detailed evaluation of relevant impact pathways on fish and shellfish ecology was undertaken in **Section 4.3** of this Screening Report, which concluded that no new or materially different effects are predicted. As such, there is no material change to the magnitude or nature of this impact pathway or its residual effect as assessed in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
	C5: Construction activities leading to additional steaming to alternative fishing grounds			No	As the Proposed Variation does not materially alter the residual effect of reduction in access to fishing grounds (impact pathway C1), any associated additional steaming to alternative fishing grounds is also not materially different to that assessed in the 2023 EIAR (GVOWL, 2023a). As such, the overall magnitude of the impact and residual effect are not materially altered by the Proposed Variation. Therefore, this impact pathway is screened out.
	C6: Increased vessel traffic within fishing grounds leading to interference with fishing activity			No	Under the Proposed Variation, the nature and scale of vessel activity remain consistent with that assessed in the 2023 EIAR (GVOWL, 2023a). The risk of interference remains localised and infrequent, with embedded mitigation measures including ongoing fisheries liaison, issuing of NtM, and adherence to navigational best practice, still in place. As such, there is no material change to the magnitude of impact or residual effect. Therefore, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O1: Reduction in access to, or exclusion from established fishing grounds			No	The Proposed Variation does not alter the consented Windfarm Site boundary (116 km^2) or the maximum number of WTGs. While some design parameters have changed, including a potential to install up to nine moorings per WTG, the 2023 EIAR (GVOWL, 2023a) assumed exclusion of mobile gear vessels within the Windfarm Site during operation. As creeling does not occur within the Windfarm Site, exclusion for this activity is limited to short-term, localised maintenance works on OECs, which are not changing under the Proposed Variation. Embedded mitigation remains in place and effective. The residual effect is not materially changed. This impact pathway is screened out.
	O2: Displacement, leading to gear conflict and increased fishing pressure adjacent grounds			No	This impact pathway is directly linked to reduction in access to fishing grounds (impact O1), which has been screened out, as there is no material change to access or spatial extent under the Proposed Variation. As such, the overall magnitude of the impact and residual effect are not materially altered by the Proposed Variation. Therefore, this impact pathway is screened out.
	O3: Physical presence offshore windfarm infrastructure leading to gear snagging			No	The Proposed Variation does not alter the consented Windfarm Site boundary (116 km^2) or the maximum number of WTGs. While some design parameters have changed, including a potential to install up to nine moorings per WTG , the 2023 EIAR (GVOWL, 2023a) assumed that fishing will be excluded from the Windfarm Site during the operational phase. Therefore, snagging risks primarily relate to the OECs, which are outside the scope of the Proposed Variation. Embedded mitigation remains in place and effective. The residual effect is not materially changed. This impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O4: Displacement or disruption of commercially important fish and shellfish resources			No	The Proposed Variation does not materially alter the predicted residual effects on fish and shellfish receptors. A detailed evaluation of relevant impact pathways on fish and shellfish ecology was undertaken in **Section 4.3** of this Screening Report, which concluded that no new or materially different effects are predicted. As such, there is no material change to the magnitude or nature of this impact pathway or its residual effect as assessed in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
	O4: O&M activities leading to additional steaming to alternative fishing grounds			No	As the Proposed Variation does not materially alter the residual effect of reduction in access to fishing grounds (impact pathway O1), any associated additional steaming to alternative fishing grounds is also not materially different to that assessed in the 2023 EIAR (GVOWL, 2023a). As such, the overall magnitude of the impact and residual effect are not materially altered by the Proposed Variation. Therefore, this impact pathway is screened out.
	O5: Increased vessel traffic within fishing grounds leading to interference with fishing activity			No	This impact pathway is directly related to impact O1, which has been screened out due to no material change to the residual effect of access or exclusion from fishing grounds during O&M. Therefore, no material change in impact magnitude or residual effect is expected. As such, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
Shipping and Navigation (Evaluated further in Section 4)	C1: Vessel displacement	Broadly acceptable to tolerable with mitigation – not significant	WTGs: The proposed changes to WTG parameters, including changes to the minimum and maximum spacing, are relevant to this receptor group and could potentially materially alter the originally assessed effects. Floating Substructures and Mooring System: The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the originally assessed effects. IACs: The proposed changes to the IAC system are relevant to this receptor group and could potentially materially alter the originally assessed effects. OSP: The proposed changes to the OSP dimensions are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	The Proposed Variation does not alter the consented boundary of the Windfarm Site, which remains at 116 km^2, or the area within which construction activities will occur. Decreased minimum spacing of 1,000 m would still be expected to facilitate transits from the smaller vessels that would be expected within the Windfarm Site. The embedded mitigation detailed in the 2023 EIAR (GVOWL, 2023a) remains relevant and sufficiently reduces the overall magnitude of the impact. As such, the magnitude of the impact is not materially different to that assessed in the 2023 EIAR (GVOWL, 2023a) and the residual effect is not materially changed. Therefore, this impact pathway is screened out.
	C2: Restriction of adverse weather routeing			No	The Proposed Variation does not change the Windfarm Site's area. No adverse weather routeing occurs within the site, and sufficient searoom remains available for vessels during adverse conditions. Existing navigation and communication measures, including Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs) compliance remain in place. Consequently, there is no material change to the impact magnitude or residual effect. This impact pathway is screened out.
	C3: Increased vessel to vessel collision risk between third-party vessels			No	The Proposed Variation does not alter the consented boundary of the Windfarm Site, which remains at 116 km^2, or the area within which construction activities will occur. Embedded mitigation from the 2023 EIAR (GVOWL, 2023a) remains applicable, ensuring safe navigation and minimising the risk of collision. No material change to impact magnitude or residual effect is expected. This impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	C4: Increased vessel to vessel collision risk between third-party vessels and Project Vessels			No	The Proposed Variation does not alter the consented boundary of the Windfarm Site, which remains at 116 km^2, or the area within which construction activities will occur. Embedded mitigation from the 2023 EIAR (GVOWL, 2023a) remains in place to minimise collision risk. No material change to impact magnitude or residual effect is expected. This impact pathway is screened out.
	C5: Vessel to structure allision risk			No	The Proposed Variation does not alter the consented boundary of the Windfarm Site, which remains at 116 km^2, or the area within which construction activities will occur. Substation topside dimensions are increasing however this is not expected to have a material impact on the assessment findings noting embedded mitigation from the 2023 EIAR (GVOWL, 2023a) remains in place to minimise allision risk. No material change to impact magnitude or residual effect is expected. This impact pathway is screened out.
	C6: Reduced access to local ports			No	The key local port, Peterhead, is located over 30 nautical miles (nm) from the Windfarm Site, no direct impact is expected. Construction vessel movements will be managed through marine coordination and adherence to COLREGS, minimising disruption. There is no material change to the impact magnitude or residual effect because of the Proposed Variation. This impact pathway is screened out.
	C7: Reduction in emergency response capability				The Proposed Variation does not materially change the impact magnitude or residual effect on emergency response capability as assessed in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O1: Vessel displacement			No	The Proposed Variation does not alter the consented boundary of the Windfarm Site, which remains at 116 km^2 and does not result in a material change to the impact magnitude or residual effect on vessel displacement. Decreased minimum spacing of 1,000 m would still be expected to facilitate transits from the smaller vessels that would be expected within the Windfarm Site. As noted in the original assessment (GVOWL, 2023a) only minor deviations to a small number of low use commercial routes were anticipated, with sufficient surrounding searoom to accommodate any changes. Therefore, this impact pathway is screened out.
	O2: Adverse weather routeing			No	The Proposed Variation does not make changes to the Windfarm Site area, and therefore it is determined that there would not be any material changes to the impact magnitude or residual effect as assessed in the 2023 EIAR (GVOWL, 2023a). Therefore, this impact pathway is screened out.
	O2: Increased vessel to vessel collision risk between third-party vessels				The Proposed Variation does not alter vessel traffic volumes or patterns in a way that would increase the risk of collisions between third-party vessels. As established in the original assessment (GVOWL, 2023a), sufficient searoom remains available for safe navigation, and no significant increase in vessel density is expected. There is no material change to the impact magnitude or residual effect. As such, this impact pathway is screened out.
	O3: Increased vessel to vessel collision risk between third-party vessels and Project Vessels			No	The Proposed Variation does not alter the consented boundary of the Windfarm Site, which remains at 116 km^2, or the maximum number of WTGs. Embedded mitigation from the 2023 EIAR (GVOWL, 2023a) remains in place to minimise collision risk. No material change to impact magnitude or residual effect is expected. This impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O4: Vessel to structure allision risk			No	The Proposed Variation does not alter the consented boundary of the Windfarm Site, which remains at 116 km^2, or the maximum number of WTGs. Substation topside dimensions are increasing however this is not expected to have a material impact on the assessment findings noting embedded mitigation from the 2023 EIAR (GVOWL, 2023a) remains in place to minimise allision risk. No material change to impact magnitude or residual effect is expected. This impact pathway is screened out.
	O5: Reduced access to local ports			No	The key local port, Peterhead, is located over 30 nm from the Windfarm Site, no direct impact is expected. O&M vessel movements will be managed through marine coordination and adherence to COLREGS, minimising disruption. There is no material change to the impact magnitude or residual effect because of the Proposed Variation. This impact pathway is screened out.
	O6: Reduction of under keel clearance			Yes	The Proposed Variation increases the maximum number of mooring lines per floating substructure from six to nine. Larger commercial vessels are unlikely to approach the floating substructures, and smaller vessels will typically have sufficient clearance. Additionally, the mooring line angle of descent is shallower, changing from 14 to 6.4, meaning a greater portion of each mooring line remains closer to the water surface for longer distances. These changes may influence under-keel clearance and increase snagging risk. These changes have the potential to increase of reduced under keel clearance for smaller vessels in the Windfarm Site compared to what was assessed in the 2023 EIAR. Given the potential for a material change in the overall magnitude of this impact pathway further evaluation is required in **Section 4.6**.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O7: Anchor snagging interaction			No	The Proposed Variation increases the maximum number of mooring lines per floating substructure from six to nine. However, this change does not materially alter the risk of anchor snagging, which remains similar to the original assessment set out in 2023 EIAR (GVOWL, 2023a). Promulgation of infrastructure locations to sea users and continued coordination with the MCA and the NLB will mitigate any potential risk. There is no material change to the impact magnitude or residual effect. This impact pathway is screened out.
	O8: Loss of station			No	The Proposed Variation does not materially change the originally assessed impact magnitude or residual effect for loss of station. Existing mitigation, including third party verification, real-time monitoring, and alarm systems, remain in place and effective. As such, this impact pathway is screened out.
	O9: Reduction in emergency response capability			No	The Proposed Variation does not materially change the impact or residual effect on emergency response capability as assessed in the 2023 EIAR (GVOWL, 2023a). Vessel and personnel levels remain similar and existing mitigation, including Marine Guidance Note 654 compliance, coordination with the MCA, and adherence to the Emergency Response Cooperation Plan, continue to apply. Search and rescue access will be maintained. As such, this impact pathway is screened out.
Offshore Archaeology and Cultural Heritage (Screened out)	C1: Direct (physical) impact to known heritage assets	Minor adverse – not significant	WTGs: The proposed changes to the WTGs are not relevant to this receptor group, as they do not affect the seabed. Floating Substructures and Mooring System:	No	The Proposed Variation does not result in any material change to the impact magnitude or residual effect on known heritage assets as assessed in the 2023 EIAR (GVOWL, 2023a). Embedded mitigation, including the avoidance of identified features and implementation of archaeological exclusion zones (AEZ) remain in place and effective. As such, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	C2: Direct impact to potential heritage assets		The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the originally assessed effects. <u>IACs:</u> The proposed changes to the IAC system are relevant to this receptor group and could potentially materially alter the originally assessed effects. <u>OSP:</u> The proposed changes to the OSP foundation are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	The Proposed Variation does not materially alter the nature and scale of the Project in a way that would change the risk of direct impact to potential heritage assets. The embedded mitigation set out in the Outline Written Scheme of Investigation (WSI) remains in place and effective. As such, no material change to the impact magnitude or residual effect is expected. This impact pathway is screened out.
	C3: Indirect impact to heritage assets from changes to physical processes			No	The original assessment concluded there would be no impact on heritage assets from physical processes. The Proposed Variation does not introduce any material change that would alter this outcome. As such, this impact pathway is screened out.
	C4: Impacts to the setting of heritage assets			No	The original assessment concluded there would be no impact on the setting of heritage assets. The Proposed Variation does not introduce any material change that would alter this outcome. As such, this impact pathway is screened out.
	O1: Direct (physical) impact to known heritage assets			No	The original assessment (2023 EIAR (GVOWL, 2023a)) concluded there would be no direct impact on known heritage assets, as AEZs will be retained throughout the lifespan of the Project. The Proposed Variation does not introduce any material change that would alter this outcome. As such, this impact pathway is screened out.
	O2: Direct impact to potential heritage assets			No	The Proposed Variation does not materially alter the nature and scale of the Project in a way that would change the risk of direct impact to potential heritage assets. The embedded mitigation set out in the Outline WSI remains in place and effective. As such, no material change to the impact magnitude or residual effect is expected. This impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O3: Indirect impact to heritage assets from changes to physical processes			No	The original assessment concluded there would be no impact on heritage assets from physical processes. The Proposed Variation does not introduce any material change that would alter this outcome. As such, this impact pathway is screened out.
	O4: Impacts to the setting of heritage assets			No	The nature or scale of the Project, under the Proposed Variation remains consistent with that originally assessed. As such, the Proposed Variation does not materially change the impact magnitude or residual effect. This impact pathway is screened out.
Aviation and Radar	C1: Temporary obstruction during tow	Not significant	WTGs: The proposed changes to WTG parameters, including changes to the maximum blade tip height, are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	The nature and scale of the Project, under the Proposed Variation remain consistent with that originally assessed. The temporary nature of WTG tow operations, combined with standard aviation notifications (e.g., Notice to Airmen), ensures no material change in the impact magnitude or residual effect. This impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O1: Radar impact		Floating Substructures and Mooring System: The proposed changes to the floating substructures and the mooring system are not relevant to this receptor group. IACs: The proposed changes to the IAC system are not relevant to this receptor. OSP Foundations: The proposed changes to the IAC system are not relevant to this receptor. OSP Topside: The proposed changes to the OSP topside do not alter the maximum height (remaining at 70 m) and are not expected to materially affect aviation and radar receptors. In the context of a floating offshore windfarm, WTGs remain the primary consideration due to their greater height.	No	The 2023 EIAR assessment established that the all the turbines would impact the key radar in the area; specifically, the Buchan air defence radar and the National Air Traffic Services en-route primary surveillance radars at Alanshill and Perwinnes. These impacts requiring mitigation. The increase in maximum blade tip height from 264 m above SWL to 289 m above SWL will not change these impacts or the requirement for mitigation. No additional radars can be affected as a result of the proposed changes. The increase in WTG dimensions does not change the maximum number of WTGs, the location of the Windfarm Site, or the area of the Windfarm Site. Mitigation is secured through s.36 Consent (Scottish Ministers, 2024a) Conditions 20 and 21, which require the approval and implementation of an Air Defence Radar Mitigation Scheme and a Primary Radar Mitigation Scheme. Given this, the change in WTG maximum tip height does not materially alter the nature or magnitude of radar impacts previously assessed. Therefore, no new or materially different environmental effects arise, this impact pathway is screened out.
	O2: Flight operation			No	The Proposed Variation does not materially change the originally assessed impact magnitude or residual effect on flight operation. Existing mitigation, including aviation obstacle lighting, and issuing the relevant notifications remain in place and effective. As such, this impact pathway is screened out.
Infrastructure and Other Marine Users (Screened out)	C1: Disturbance of existing offshore windfarms	Negligible to minor adverse – not significant	WTGs: The proposed changes to WTG parameters, including changes to the WTG spacing, are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	The Proposed Variation does not materially change the nature or scale of construction activities affecting existing offshore windfarms and the consented Windfarm Site boundary remains at 116 km^2. Embedded mitigation, including coordination, notifications, and cable crossing agreements, remain in place and effective. There is no material change to the impact magnitude and residual effect. This impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	C2: Disturbance to oil and gas operations		Floating Substructures and Mooring System: The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the originally assessed effects. IACs: The proposed changes to the IAC system are relevant to this receptor group and could potentially materially alter the originally assessed effects. OSP: The proposed changes to the OSP foundation are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	The Proposed Variation does not materially change the Project's scale or location in relation to O&G operations. Embedded mitigation, including communication protocols, proximity agreements where required, and vessel coordination, remain in place effective. The impact magnitude and residual effect are consistent with the original assessment (GVOWL, 2023a). There is no material change to the impact magnitude or residual effect. This impact pathway is screened out.
	C3: Disturbance of marine disposal sites			No	The Proposed Variation does not materially change the Project's scale or location in relation to marine disposal sites. There are no marine disposal sites in close proximity to the Windfarm Site. Mitigation remains unchanged and effective. There is no material change to the impact magnitude or residual effect. This impact pathway is screened out.
	C4: Disturbance of existing subsea cables and pipelines			No	The Proposed Variation increases the maximum number of cable/pipeline crossings but does not materially change the nature and scale of the impact. Established mitigation, including crossing agreements and protective rock layers or mattresses, remain in place and effective. Therefore, the impact magnitude and residual effect remain consistent with the original assessment. This impact pathway is screened out.
	O1: Disturbance of existing offshore windfarms			No	The Proposed Variation does not materially change the Project's scale or location in relation to existing offshore windfarms. Embedded mitigation remains in place and effective. There is no material change to the impact magnitude and residual effect. This impact pathway is screened out.
	O2: Disturbance to oil and gas operations			No	The Proposed Variation does not materially change the Project's scale or location in relation to existing O&G operations. Embedded mitigation remains in place and effective. There is no material change to the impact magnitude and residual effect. This impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O3: Disturbance of marine disposal sites			No	The Proposed Variation does not materially change the Project's scale or location in relation to marine disposal sites. Embedded mitigation remains in place and effective. There is no material change to the impact magnitude and residual effect. This impact pathway is screened out.
	O4: Disturbance of existing subsea cables and pipelines			No	The nature or scale of the Project, under the Proposed Variation remains consistent with that originally assessed. As such, the Proposed Variation does not materially change the impact magnitude or residual effect. This impact pathway is screened out.
Climate Change (Screened out)	C1: Greenhouse Gas (GHG) emissions during construction	Beneficial	WTGs: The proposed changes to the WTGs are relevant to this receptor group and could potentially materially alter the originally assessed effects. Floating Substructures and Mooring System: The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the originally assessed effects. IACs: The proposed changes to the IAC system are relevant to this receptor group and could potentially materially alter the originally assessed effects. OSP: The proposed changes to the OSP foundation and topside are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	The Proposed Variation does not materially change the nature or scale of the Project or its GHG emissions profile. The Project continues to provide a renewable source of electricity, reducing atmospheric GHG concentrations compared to the without project baseline of natural gas generation. Therefore, the impact magnitude and residual effect remain beneficial. This impact pathway is screened out.
	O1: GHG emissions during operation			No	

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
Socioeconomics, Tourism, and Recreation (Screened out)	C1: Direct employment	Negligible to moderate beneficial – not significant Major beneficial – significant Negligible to minor adverse – not significant	WTGs: The proposed changes to the WTGs are relevant to this receptor group and could potentially materially alter the originally assessed effects. Floating Substructures and Mooring System: The proposed changes to the floating substructures and in particular the mooring system are relevant to this receptor group and could potentially materially alter the originally assessed effects. IACs: The proposed changes to the IAC system are relevant to this receptor group and could potentially materially alter the originally assessed effects. OSP: The proposed changes to the OSP are relevant to this receptor group and could potentially materially alter the originally assessed effects.	No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.
	C2: Supply chain impacts			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.
	C3: Increase in demand for local private services/goods			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.
	C4: Interference with planned infrastructure improvements in the local area			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.
	C5: Impact on marine tourism			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	C6: Disturbance of recreational activities			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.
	C7: Construction activities leading to additional steaming to alternative fishing grounds			No	The 2023 EIAR (GVOWL, 2023a) assessed the residual effect of construction activities leading to additional steaming to alternative fishing grounds as not significant within the Commercial Fisheries Chapter. This Screening Report has screened all commercial fisheries impact pathways and concluded that the Proposed Variation does not materially alter the magnitude of impact nor the residual effect. As such, this impact pathway is screened out.
	O1: Direct employment			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.
	O2: Supply chain impacts			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.
	O3: Increase in demand for local private services/goods			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.

Receptor Topic	Impacts Assessed in the 2023 EIAR	Residual Effect Predicted in 2023 EIAR	Implication of the Proposed Variation	Further Evaluation Required within this Screening Report (Section 4)	Screening Rationale
	O4: Interference with planned infrastructure improvements in the local area			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.
	O5: Impact on marine tourism			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.
	O6: Disturbance of recreational activities			No	The Proposed Variation does not materially alter the nature, scale, or location of the Project assessed in the 2023 EIAR (GVOWL, 2023a). As such, the Proposed Variation does not result in a material change to either the magnitude of impacts or residual effects on socio-economic receptors. Therefore, this impact pathway is screened out.
	O7: Operation activities leading to additional steaming to alternative fishing grounds			No	The 2023 EIAR (GVOWL, 2023a) assessed the residual effect of O&M activities leading to additional steaming to alternative fishing grounds as not significant within the Commercial Fisheries Chapter. This Screening Report has screened all commercial fisheries impact pathways and concluded that the Proposed Variation does not materially alter the magnitude of impact nor the residual effect. As such, this impact pathway is screened out.

B Appendix – Updated Seabird Collision Risk Modelling

Green Volt Offshore Windfarm Ltd.

Collision Risk Modelling Technical Report

Toby Phelps, Dr Rob Catalano & Matthew Boa

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1.2	18/07/2025	All	All	Finalised draft	TP

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1. Introduction

1.1 Project Background

Green Volt Offshore Windfarm Ltd. (GVOWL; the Developer) was granted offshore consent by the Scottish Ministers to construct and operate the Green Volt Offshore Windfarm (OWF; Scottish Government, 2024), a floating OWF and associated offshore transmission assets (hereafter referred to as 'the Project'), approximately 80 km east of Peterhead, Aberdeenshire, with the Windfarm Site having a total area of 116 km^2. The Project will have a generating capacity of up to 560 MW produced by up to 35 offshore Wind Turbine Generators (WTGs) including offshore infrastructure; export cables to the Buzzard oil and gas platform complex, and export cables to landfall for connection to onshore transmission infrastructure and the UK electricity network (further details on the Project design are presented in **Green Volt Offshore Windfarm Environmental Impact Assessment Report Volume 1: Technical Chapters Chapter 5: Project Description** (GVOWL, 2023a).

As presented within **Green Volt Offshore Windfarm Environmental Impact Assessment Report Chapter 12: Offshore and Intertidal Ornithology** (GVOWL, 2023b) and the **Supplementary Ornithological Assessment** (APEM, 2023), Collision Risk Modelling (CRM) was completed for a range of WTG scenarios, with subsequent impact assessments undertaken against the Worst-Case Scenario (WCS) design (turbine scenario predicting the highest number of collision mortalities per annum) in relation to potential impacts on ornithological features.

APEM Ltd (hereafter APEM) was commissioned by the Project to undertake CRM for additional turbine design scenarios to supplement the Project's consent variation request and inform whether the turbine designs short-listed would materially change any assessment conclusions.

1.2 Collision Risk Modelling

There is the potential for birds flying through the OWF to collide with the rotating turbines and associated infrastructure, which would then be predicted to result in mortality (Drewitt & Langston, 2006). This potential collision risk can be estimated by modelling the predicted number of collisions for key seabird species using the known densities of birds in flight within the array area, as determined from the baseline surveys.

Four key seabird species were previously identified (as detailed within **EIA Report Chapter 12, Technical Appendix 12.3 Offshore Ornithology: Collision Risk Modelling** (APEM, 2022)) as being potentially as risk of collision for the Project, as agreed with relevant stakeholders:

- Kittiwake (*Rissa tridactyla*);
- Gannet (*Morus bassanus*);
- Herring gull (*Larus argentatus*); and
- Great black-backed gull (*Larus marinus*)

All modelling and subsequent assessment presented within this report has been completed for the four species previously modelled, to understand if the proposed new WCS designs will materially affect the level of impact predicted.

2. WTG Design Options Analysis

2.1 Methods

2.1.1 Guidance and models

To ensure model consistency with the approach taken and presented within the **Supplementary Ornithological Assessment** (APEM, 2023), CRM was undertaken using the stochastic Collision Risk Model (sCRM), developed by Marine Scotland (Mc Gregor *et al.* 2018). In line with previous modelling, both stochastic and deterministic results have been produced. At the time of the Project undertaking modelling to inform consent, this was the most up to date sCRM available and was the model previously advocated within NatureScot's Guidance Note 7 (NatureScot, updated 2025) at the time of drafting the supplementary information report. Since submission of the **Supplementary Ornithological Assessment** (APEM, 2023), NatureScot have updated Guidance Note 7 to now recommend the use of the Caneco and Humpries (2022) version of the sCRM, which was developed to provide an improved user experience over the McGregor et al (2018) version. The modelling process between the two sCRMs is the same and therefore not expected to materially change any modelling predictions.

The sCRM can generate collision estimates by two different methods (basic and extended models), each of which have two different options. The basic model assumes a uniform flight height distribution across the rotor swept heights, whilst the extended model uses species-specific modelled flight height distributions to account for variation in the distribution of flights across the rotor swept heights (Band, 2012; Johnston et al., 2014a, b). Seabird flight height distributions tend to be skewed towards the lower rotor swept heights, where collision risk is lower (Band, 2012), so that for most species the extended model will give lower collision estimates than the basic for a given avoidance rate and set of wind farm parameters.

Each of the basic and extended models can be run using either site-specific flight height data (i.e. as collected from the array area in question) or generic flight height data, which is derived from pre-construction surveys for wind farm developments at 32 sites in the UK and elsewhere in Europe (Johnston et al., 2014a, b). This gives rise to Options 1 (site-specific flight height data) and 2 (generic flight height data) for the basic model, and Options 3 (generic flight height data) and 4 (site-specific flight height data) for the extended model (Band, 2012).

No site-specific flight height data was available for the Project therefore generic flight height data has been used only. In relation to Band Option 3, NatureScot Guidance Note 7 (NatureScot, updated 2025), currently states that there are no agreed upon avoidance rates for the extended model for use within the sCRM. Therefore, for consideration of collision risk presented within this report, Band Option 2 outputs have been relied upon only. The use of Band Option 2 is consistent with the approach taken for modelling presented within **Green Volt Offshore Wind Farm Environmental Impact Assessment Report Chapter 12: Offshore and Intertidal Ornithology** (GVOWL, 2023b) and the **Supplementary Ornithological Assessment** (APEM, 2023).

In 2024, UK Statutory Nature Conservation Bodies (SNCBs) published a joint advice note regarding bird collision risk modelling for offshore wind developments (SNCBs, 2024). This guidance note provides updated recommendations for biometric input parameters for seabirds based on SNCBs interpretation of current available evidence. Such recommended parameters have been utilised within this report as detailed within **Section 2.1.3**.

2.1.2 WTG parameters

Standardised input parameters across the two WTG scenarios modelled are presented within **Table 2-1**. The estimated percentage of time that the WTGs are predicted to be operational per month (average across all turbines) is presented in **Table 2-2**. For clarity, operational proportions remain the same as previously modelled to inform assessments presented within the **Supplementary Ornithological Assessment** (APEM, 2023). Parameters which vary across the two scenarios and the previously modelled scenario within the **Supplementary Ornithological Assessment** (APEM, 2023) are presented within **Table 2-3**.

Table 2-1 WTG and Array parameters consistently applied across all OWF scenarios for Collision Risk Assessment.

Input Parameter	Standardised values
Number of blades	3
Tidal offset (m)	0
Maximum footprint width (km)	16.93
Latitude (degrees)	57.88
Large array correction	Yes

Table 2-2 Theoretical WTG operational time per month.

Month	Operational Time (%)	Mean downtime (%)	Standard Deviation (SD) downtime (%)
January	98.8	0	0
February	98.7	0	0
March	97.6	0	0
April	86.5	0	0
May	92.1	0	0
June	78.6	0	0
July	87.9	0	0
August	94.9	0	0
September	94.2	0	0
October	93.0	0	0
November	83.9	0	0
December	89.0	0	0

Table 2-3 WTG parameters that vary between OWF scenarios for Collision Risk Assessments.

Modelling Scenario		No. of WTGs	Turbine model (MW)	Rotor radius (m)	Min. air gap* (m)	Hub height* (m)	Rotation speed (rpm)	Pitch (º)	Max. blade width (m)
1	Consented WCS**	35	16	121	22	143	8	6	8
2	New worst-case 14MW turbine	35	14	118	22	140	7.88	1.46	6.50
3	New worst-case 18.5MW turbine	30	18.5	130	22	152	7.00	0.60	6.81

Table Note: * Minimum air gap and hub height values expressed against Highest Astronomical Tide (HAT). **The Consented WCS design is based on the updated guidance assessment previously presented within the Supplementary Ornithological Assessment (APEM, 2023).

2.1.3 Seabird biometrics and avoidance rates

A number of physical and behavioural characteristics were used to inform CRM. Seabird biometric input parameters were derived from the input values recommended within the joint advice note regarding bird collision risk modelling for offshore wind developments (SNCBs, 2024), the recommendations of which have been included within the latest NatureScot Guidance Note 7 update (NatureScot, 2025). A summary of input parameters are presented in **Table 2-4** to **Table 2-7**. The changes in input parameters in contrast to those used to inform assessments within the **Supplementary Ornithological Assessment** (APEM, 2023) are summarised as follows:

- Basic avoidance rates for kittiwake and gannet were changed to 0.9929 (SD of ±0.0003) for stochastic modelling and 0.9923 for deterministic modelling, from the previous values of 0.993 and 0.992, respectively.
- Basic avoidance rate for herring gull and great black-backed gull was changed to 0.9936 for deterministic modelling from the previous value 0.9940 for both species.
- The nocturnal activity rate for gannet was changed to 0.14 in both models (SD of ±0.10 for stochastic modelling) from 0.08.
- The nocturnal activity rate for kittiwake was changed to 0.40 (SD of ±0.12 for stochastic modelling) from 0.375.
- The flight type for gannet was changed from gliding to flapping.

Since most birds will exhibit avoidance behaviour when faced with WTGs, a key element of collision risk modelling is the inclusion of a parameter to describe this behaviour. Different species are expected to avoid wind farms to differing degrees (Cook *et al.* 2012; Johnston *et al.* 2014a). The species-specific avoidance rates that were applied in the CRM are presented in **Table 2-5** for stochastic modelling and **Table 2-7** for deterministic modelling . The avoidance rates for all species modelled, are derived from the joint advice note regarding bird collision risk modelling for offshore wind developments (SNCBs, 2024).

Table 2-4 Species biometric data used to inform stochastic modelling, with SDs provided in brackets (SNCBs, 2024).

Parameter	Species			
	Kittiwake	Gannet	Herring gull	Great black-backed gull
Body Length (m)	0.39 (±0.0050)	0.94 (±0.0325)	0.60 (±0.0225)	0.71 (±0.0350)
Wingspan (m)	1.08 (±0.0625)	1.72 (±0.0375)	1.44 (±0.030)	1.58 (±0.0375)
Flight Speed (m/s)	13.1 (±0.40)	14.9 (±0.00)	12.8 (±1.80)	13.7 (±1.20)
Nocturnal Activity Rate	0.40 (±0.1200)	0.14 (±0.1000)	0.375 (±0.0637)	0.375 (±0.0637)
Flight Type	Flapping	Flapping	Flapping	Flapping

Table 2-5 Avoidance rates used to inform stochastic modelling (SNCBs, 2024).

Species	Basic Avoidance Rate (BO2)	
	Estimate	SD
Kittiwake	0.9929	±0.0003
Gannet	0.9929	±0.0003
Herring gull	0.9940	±0.0004
Great black-backed gull	0.9940	±0.0004

Table 2-6 Species biometric data used to inform deterministic modelling (SNCBs, 2024).

Parameter	Species			
	Kittiwake	Gannet	Herring gull	Great black-backed gull
Body Length (m)	0.39	0.94	0.60	0.71
Wingspan (m)	1.08	1.72	1.44	1.58
Flight Speed (m/s)	13.1	14.9	12.8	13.7
Nocturnal Activity Rate	0.40	0.14	0.25 – 0.50	0.25 – 0.50
Flight Type	Flapping	Flapping	Flapping	Flapping

Table 2-7 Avoidance rates used to inform deterministic modelling (SNCBs, 2024).

Species	Basic Avoidance Rate (BO2)
Kittiwake	0.9923
Gannet	0.9923
Herring gull	0.9936
Great black-backed gull	0.9936

2.1.4 Species densities

Density estimates were determined for the Project using data collected across 24 months of site-specific baseline digital aerial surveys, carried out between May 2020 and April 2022. The density data that were applied in the CRM are presented in **Table 2-8**. The density estimates in **Table 2-8** remain the same as previously modelled within **EIA Report Chapter 12, Technical Appendix 12.3 Offshore Ornithology: Collision Risk Modelling** (APEM, 2022) and subsequently used to inform assessments within **Supplementary Ornithological Assessment** (APEM, 2023).

2.1.4.1 *Gannet macro-avoidance behaviour*

In accordance with the joint advice note regarding bird collision risk modelling for offshore wind developments (SNCBs, 2024), it is recommended that CRM for gannet should include consideration of macro-avoidance. This behaviour is similar to displacement but affects flying birds only, reducing the number of birds entering an OWF site compared to what might be expected in the absence of the OWF (SNCBs, 2024).

Due to differing advice between SNCBs on the application of macro avoidance within assessment, no specific advice is provided within the joint guidance note (SNCBs, 2024). The approach taken by the Project has therefore been informed by available documentation detailing NatureScot's advice for other OWF developments (e.g. Caledonia OWF Volume 7B Appendix 6-3 Offshore Ornithology Collision Risk Modelling Technical Report and Volume 7B Appendix 6-6 Offshore Ornithology Consultation Agreement Log). For Caledonia OWF, NatureScot advised the use of a 70% macro-avoidance rate for gannet in the non-breeding season only (October – March). Therefore, this recommended rate was applied to the monthly in-flight densities during the non-breeding seasons, while densities for the migration-free breeding season (April – September) were unchanged.

Available guidance does not provide advice on the treatment of the standard deviation around the mean in-flight density estimates for macro-avoidance. Therefore, it was considered that standard deviations around monthly in-flight densities should be reduced in line with the macro-avoidance rate of 70%. This approach was applied to standard deviations around non-breeding season densities only.

Table 2-8 Species monthly density estimates used to inform CRM.

Species		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kittiwake	Mean	0.15	0.07	0.16	0.11	0.11	0.25	0.29	0.02	0.23	0.09	0.37	0.23
	SD	0.03	0.02	0.12	0.05	0.00	0.21	0.11	0.00	0.00	0.00	0.18	0.18
Gannet	Mean	0.24	0.09	0.09	0.15	0.17	0.40	0.44	0.12	0.52	0.05	0.02	0.00
	SD	0.03	0.02	0.12	0.04	0.00	0.21	0.11	0.00	0.00	0.00	0.18	0.18
Gannet (70% non-breeding macro avoidance)	Mean	0.07	0.03	0.03	0.15	0.17	0.40	0.44	0.12	0.52	0.02	0.01	0.00
	SD	0.01	0.01	0.04	0.04	0.00	0.21	0.11	0.00	0.00	0.00	0.05	0.05
Herring gull	Mean	0.33	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04
	SD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.04
Great black-backed gull	Mean	0.24	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.04
	SD	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.02

2.1.5 *Species seasonal definitions*

The seasons for each species are presented in **Table 2-9** and **Table 2-10** . To present predicted collision mortalities seasonally, the monthly values were split evenly between the return migration and breeding seasons in April for kittiwake. The seasonal definitions in **Table 2-9** and **Table 2-10** align with those previously defined and subsequently assessed within the **Supplementary Ornithological Assessment** (APEM, 2023).

Table 2-9 Seasonal definitions for kittiwake and gannet

Species	Seasons		
	Return migration	Migration-free breeding	Post-breeding migration
Kittiwake	January - mid-April	Mid-April - August	September - December
Gannet	December - March	April - September	October - November

Table 2-10 Seasonal definitions for herring gull and great black-backed gull

Species	Seasons	
	Breeding	Non-breeding
Herring gull	April – August	September – March
Great black-backed gull	April – August	September – March

2.2 Results

This section provides a summary of CRM results for all seabird species modelled in relation to the WTG design scenarios being considered. CRM results are provided seasonally in **Table 2-11** to **Table 2-20** and comparisons are provided (**Figure 2-1** to **Figure 2-6**) between seasonal predicted collisions for the consented WCS and the additional WTG designs considered.

2.2.1 Stochastic CRM results

2.2.1.1 Kittiwake

Table 2-11 Kittiwake comparison of seasonal predicted collisions for the consented WCS (1) and the additional WTG designs for consideration (2 and 3), modelled stochastically.

Season	Modelling scenario		
	1 Consented WCS	2 New worst-case 14MW turbine	3 New worst-case 18.5MW turbine
Return migration	3.05	2.62	2.31
Migration-free breeding	5.79	4.96	4.40
Post-breeding migration	5.66	4.81	4.30
Annual	**14.50**	**12.39**	**11.01**

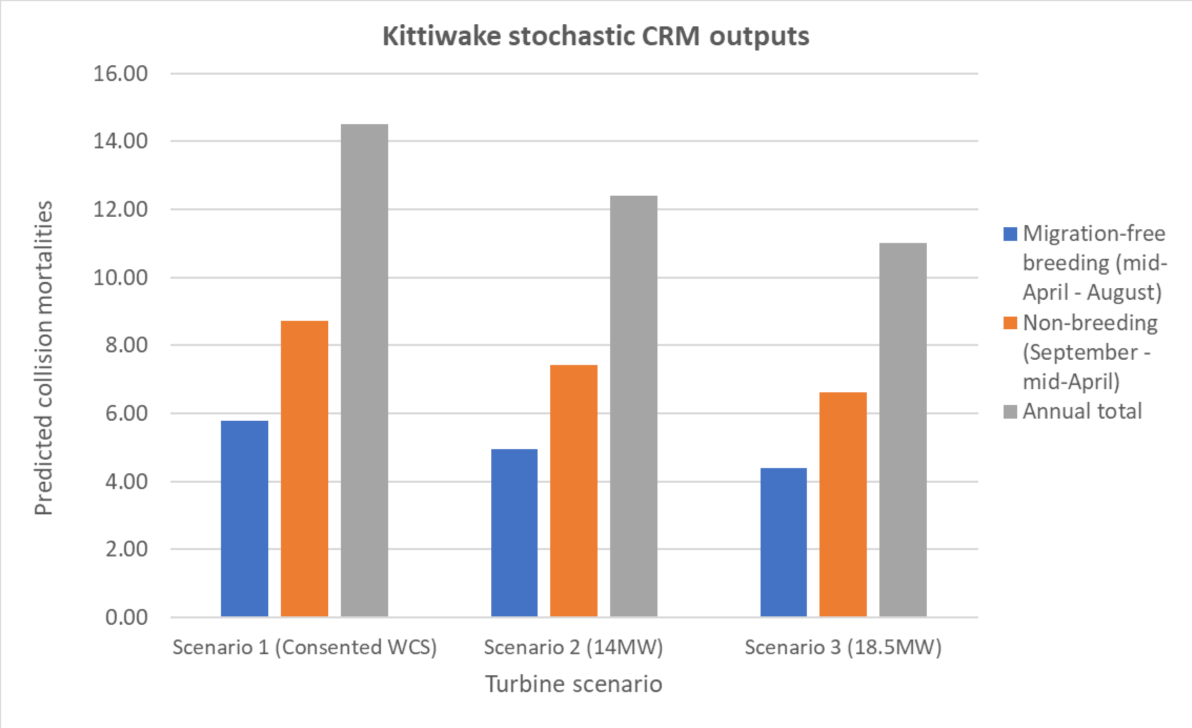

Figure 2-1 Predicted collision mortality for kittiwake by season and annual total, modelled stochastically. The return migration and post breeding migration seasons are presented as a single non-breeding impact total within the figure.

2.2.1.2 Gannet

Table 2-12 Gannet comparison of seasonal predicted collisions for the consented WCS (1) and the additional WTG designs for consideration (2 and 3), excluding macro-avoidance, modelled stochastically.

Season	Modelling scenario		
	1 Consented WCS	2 New worst-case 14MW turbine	3 New worst-case 18.5MW turbine
Return migration	2.68	2.36	2.11
Breeding	15.33	13.50	11.79
Post-breeding migration	0.70	0.61	0.54
Annual	**18.71**	**16.47**	**14.44**

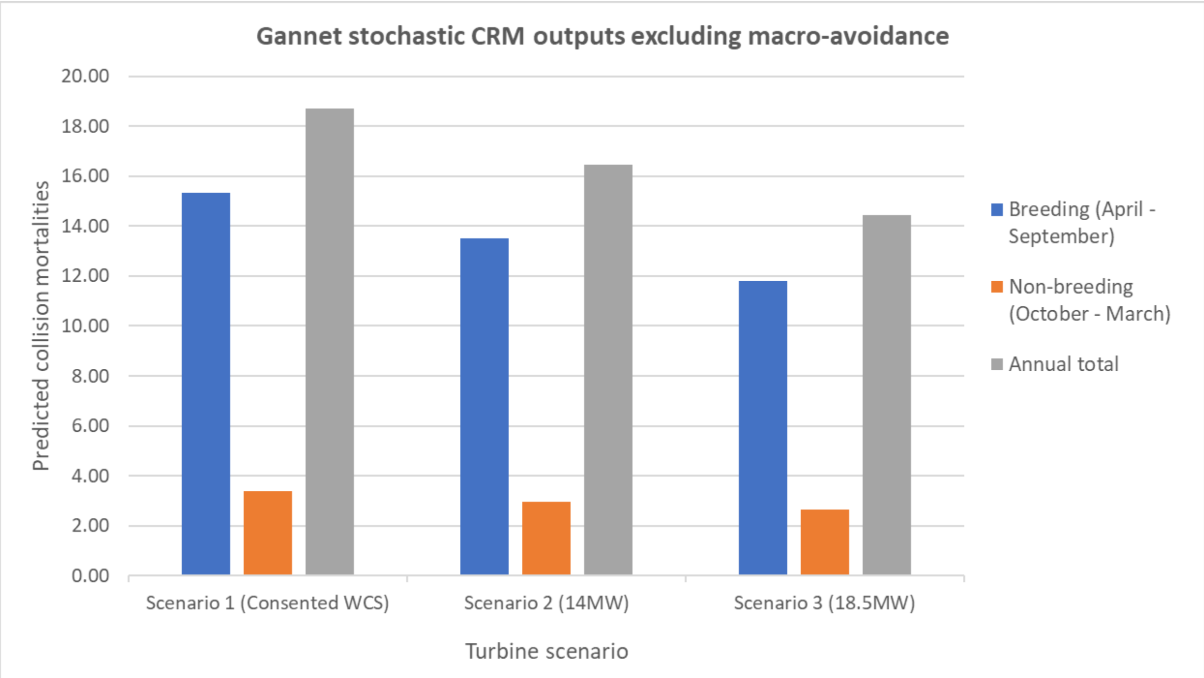

Figure 2-2 Predicted collision mortality for gannet by season and annual total, excluding macro-avoidance, modelled stochastically. The return migration and post breeding migration seasons are presented as a single non-breeding impact total within the figure.

2.2.1.3 Gannet (70% macro avoidance in the non-breeding seasons)

Table 2-13 Gannet comparison of seasonal predicted collisions for the WCS at application (1) and the additional WTG designs for consideration (2 and 3), including 70% macro-avoidance in the non-breeding season, modelled stochastically.

Season	Modelling scenario		
	1 Consented WCS	2 New worst-case 14MW turbine	3 New worst-case 18.5MW turbine
Return migration	0.81	0.71	0.63
Breeding	15.42	13.47	11.81
Post-breeding migration	0.20	0.18	0.16
Annual	**16.43**	**14.36**	**12.60**

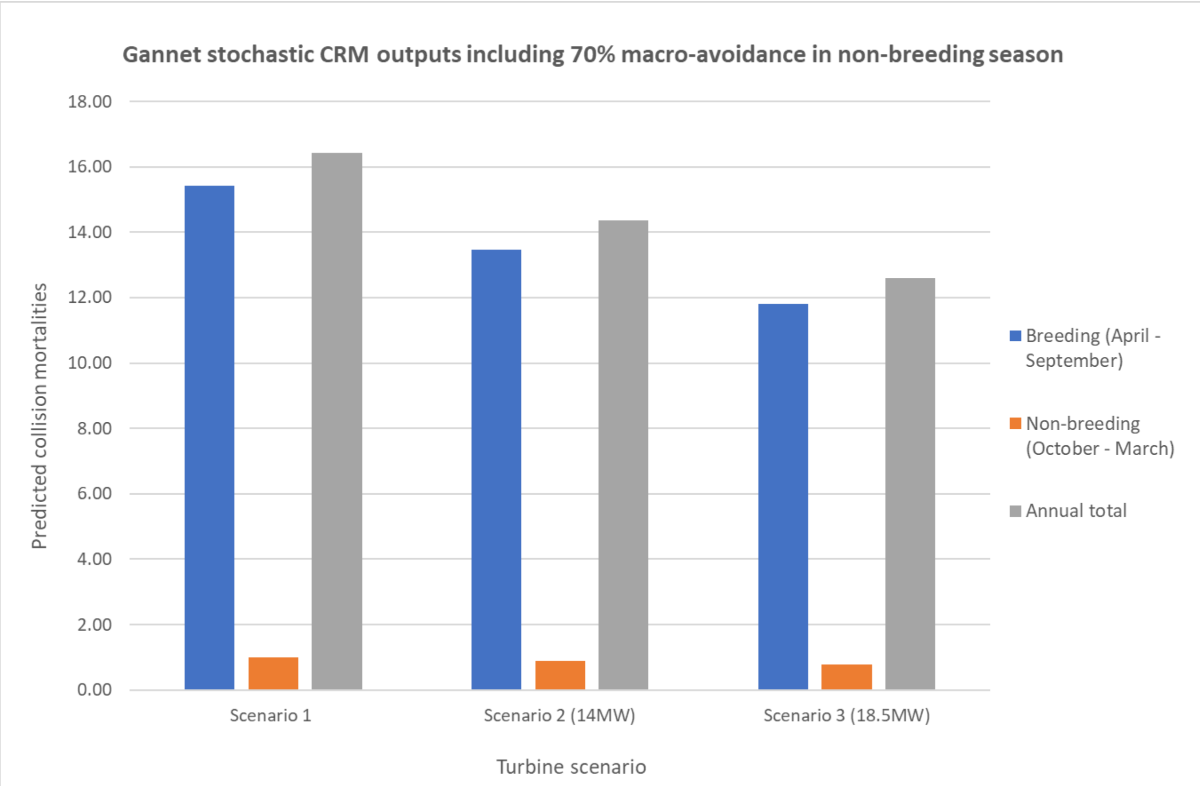

Figure 2-3 Predicted collision mortality for gannet by season and annual total, including macro-avoidance in the non-breeding season, modelled stochastically. The return migration and post breeding migration seasons are presented as a single non-breeding impact total within the figure.

2.2.1.4 *Herring gull*

Table 2-14 herring gull comparison of seasonal predicted collisions for the WCS at application (1) and the additional WTG designs for consideration (2 and 3), modelled stochastically.

Season	Modelling scenario		
	1 Consented WCS	2 New worst-case 14MW turbine	3 New worst-case 18.5MW turbine
Breeding	0.00	0.00	0.00
Non-breeding	5.65	4.95	4.32
Annual	**5.65**	**4.95**	**4.32**

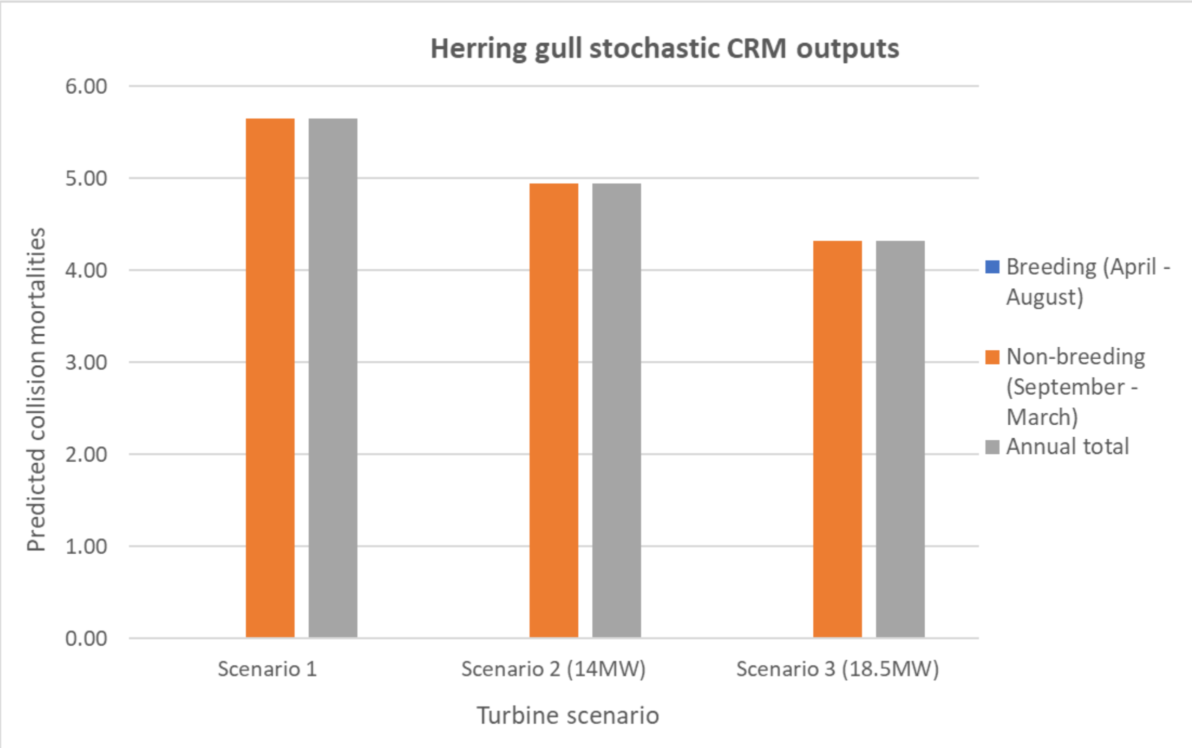

Figure 2-4 Predicted collision mortality for herring gull by season and annual total, modelled stochastically.

2.2.1.5 Great black-backed gull

Table 2-15 Great black-backed gull comparison of seasonal predicted collisions for the WCS at application (1) and the additional WTG designs for consideration (2 and 3), modelled stochastically.

Season	Modelling scenario		
	1 Consented WCS	2 New worst-case 14MW turbine	3 New worst-case 18.5MW turbine
Breeding	0.00	0.00	0.00
Non-breeding	6.26	5.50	4.75
Annual	**6.26**	**5.50**	**4.75**

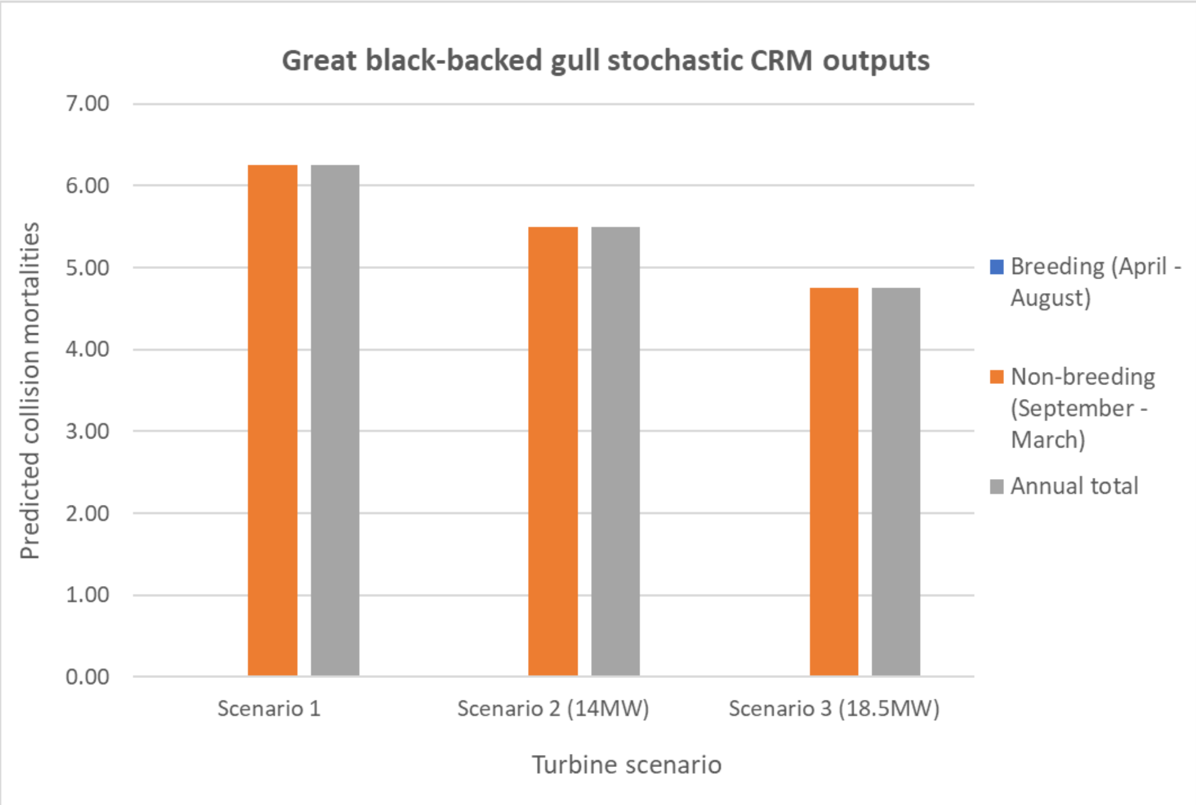

Figure 2-5 Predicted collision mortality for great black-backed gull by season and annual total, modelled stochastically.

2.2.2 Deterministic CRM results

2.2.2.1 Kittiwake

Table 2-16 Kittiwake comparison of seasonal predicted collisions for the WCS at application (1) and the additional WTG designs for consideration (2 and 3), modelled deterministically.

Season	Modelling scenario		
	1 Consented WCS	2 New worst-case 14MW turbine	3 New worst-case 18.5MW turbine
Return migration	3.10	2.65	2.35
Migration-free breeding	5.88	5.02	4.45
Post-breeding migration	5.85	5.00	4.44
Annual	**14.83**	**12.66**	**11.24**

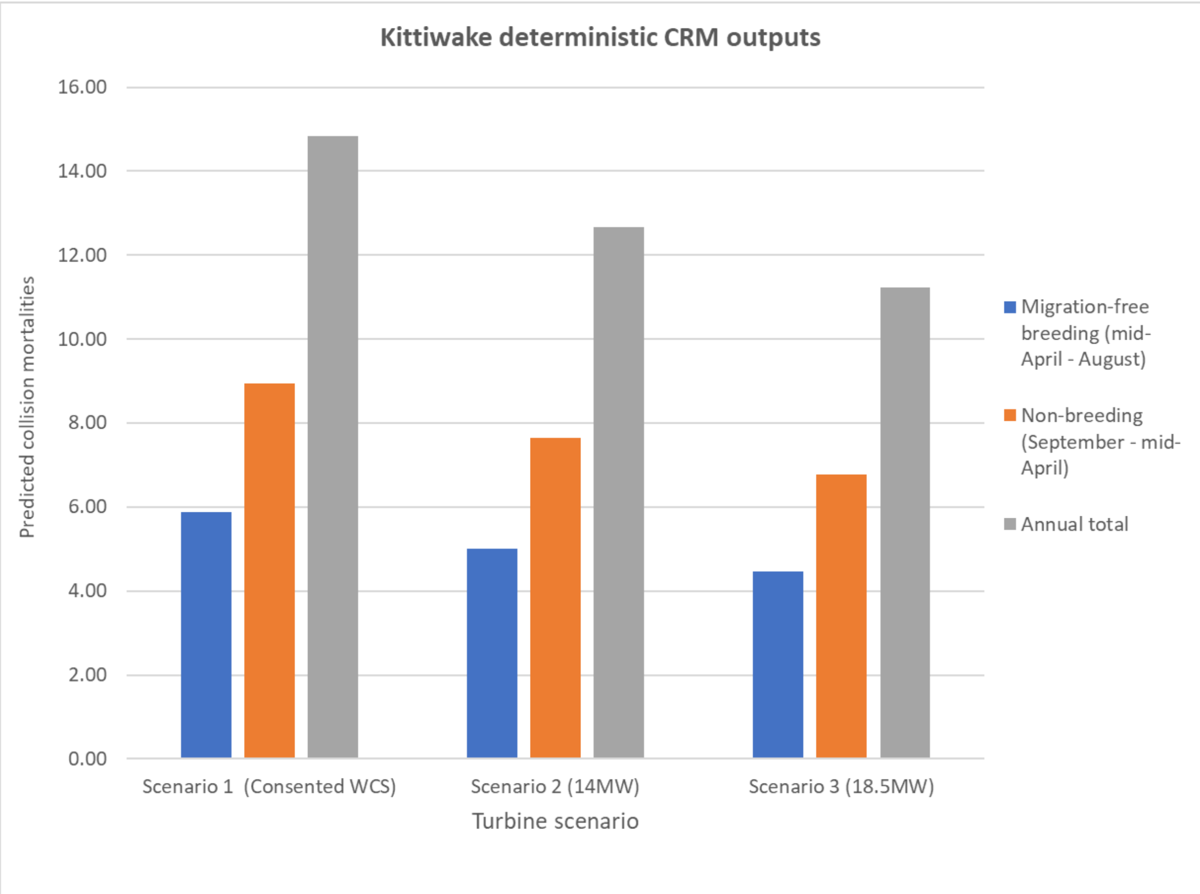

Figure 2-6 Predicted collision mortality for kittiwake by season and annual total, modelled deterministically. The return migration and post breeding migration seasons are presented as a single non-breeding impact total within the figure.

2.2.2.2 Gannet

Table 2-17 Gannet comparison of seasonal predicted collisions for the WCS at application (1) and the additional WTG designs for consideration (2 and 3), excluding macro-avoidance, modelled deterministically.

Season	Modelling scenario		
	1 Consented WCS	2 New worst-case 14MW turbine	3 New worst-case 18.5MW turbine
Return migration	2.43	2.13	1.87
Breeding	15.09	13.21	11.61
Post-breeding migration	0.42	0.36	0.32
Annual	**17.94**	**15.70**	**13.80**

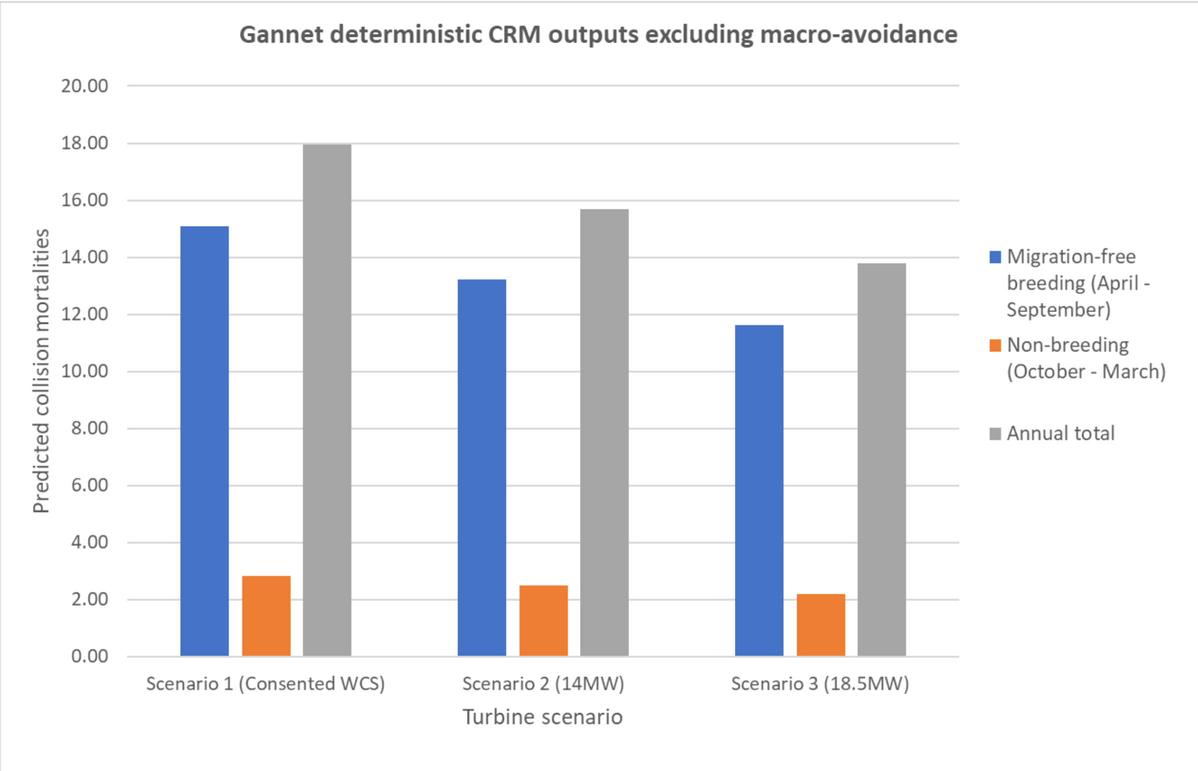

Figure 2-7 Predicted collision mortality for gannet by season and annual total, excluding macro-avoidance, modelled deterministically. The return migration and post breeding migration seasons are presented as a single non-breeding impact total within the figure.

2.2.2.3 Gannet (70% macro avoidance in non-breeding season)

Table 2-18 Gannet comparison of seasonal predicted collisions for the WCS at application (1) and the additional WTG designs for consideration (2 and 3), including 70% macro-avoidance in the non-breeding season, modelled deterministically.

Season	Modelling scenario		
	1 Consented WCS	2 New worst-case 14MW turbine	3 New worst-case 18.5MW turbine
Return migration	0.73	0.64	0.57
Breeding	15.10	13.21	11.61
Post-breeding migration	0.12	0.11	0.09
Annual	**15.95**	**13.96**	**12.27**

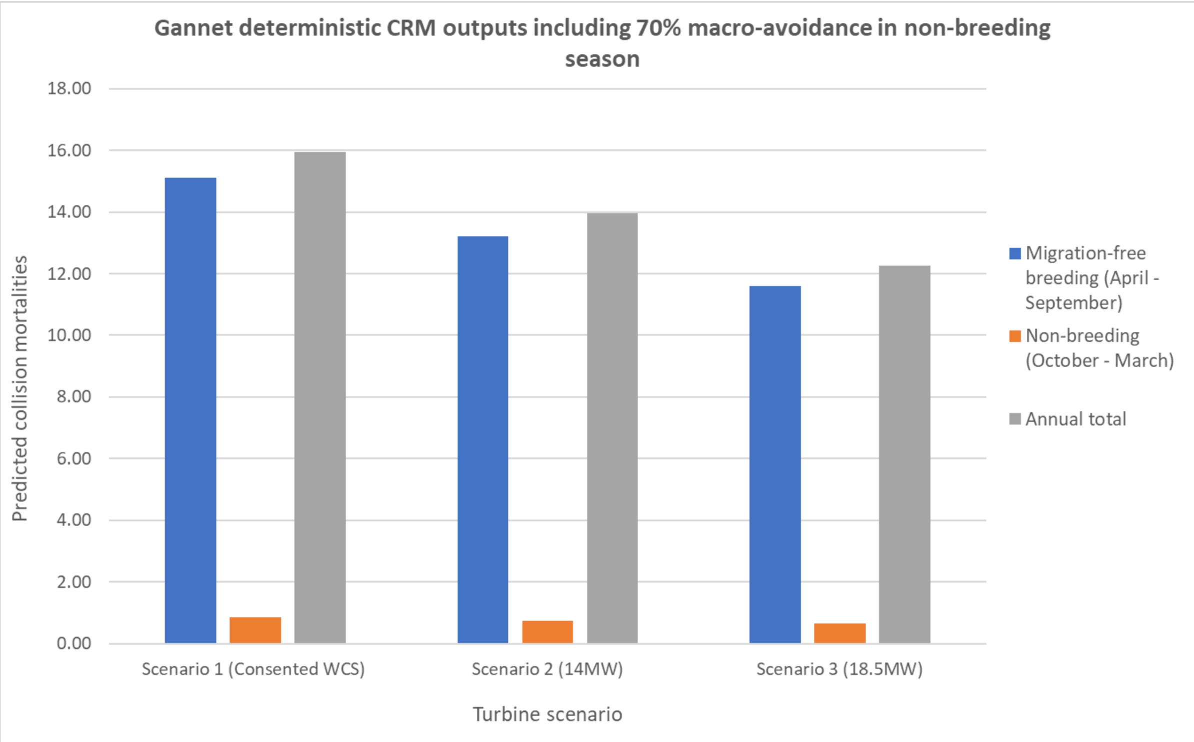

Figure 2-8 Predicted collision mortality for gannet by season and annual total, including macro-avoidance in the non-breeding season, modelled deterministically. The return migration and post breeding migration seasons are presented as a single non-breeding impact total within the figure.

2.2.2.4 Herring gull

Table 2-19 herring gull comparison of seasonal predicted collisions for the WCS at application (1) and the additional WTG designs for consideration (2 and 3), modelled deterministically.

Season	Modelling scenario		
	1 Consented WCS	2 New worst-case 14MW turbine	3 New worst-case 18.5MW turbine
Breeding	0.00 – 0.00	0.00 – 0.00	0.00 – 0.00
Non-breeding	4.86 – 6.59	4.21 – 5.71	3.70 – 5.02
Annual	**4.86 – 6.59**	**4.21 – 5.71**	**3.70 – 5.02**

Table Note: A range of collision predictions is presented to account for the nocturnal activity factor values of 25% and 50% modelled.

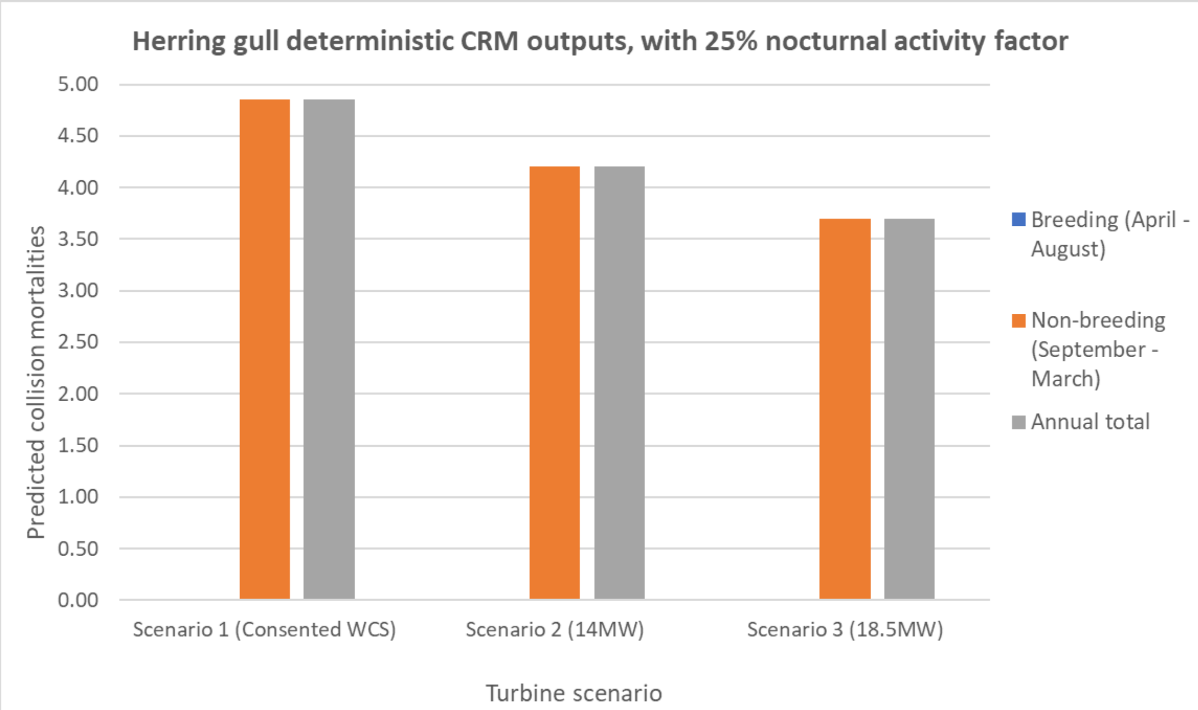

Figure 2-9 Predicted collision mortality for herring gull by season and annual total, using a 25% nocturnal activity factor, modelled deterministically.

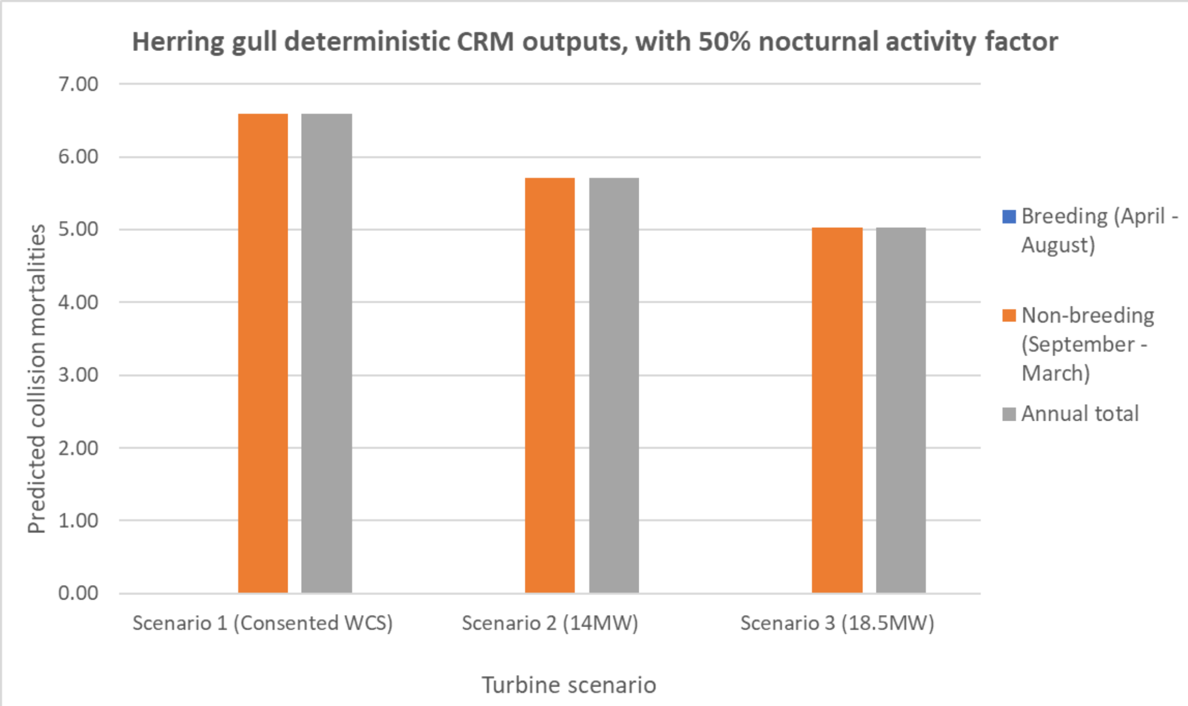

Figure 2-10 Predicted collision mortality for herring gull by season and annual total, using a 50% nocturnal activity factor, modelled deterministically.

2.2.2.5 Great black-backed gull

Table 2-20 Great black-backed gull comparison of seasonal predicted collisions for the WCS at application (1) and the additional WTG designs for consideration (2 and 3), modelled deterministically.

Season	Modelling scenario		
	1 Consented WCS	2 New worst-case 14MW turbine	3 New worst-case 18.5MW turbine
Breeding	0.00 – 0.00	0.00 – 0.00	0.00 – 0.00
Non-breeding	5.50 – 7.38	4.79 – 6.42	4.20 – 5.63
Annual	**5.50 – 7.38**	**4.79 – 6.42**	**4.20 – 5.63**

Table Note: A range of collision predictions is presented to account for the nocturnal activity factor values of 25% and 50% modelled.

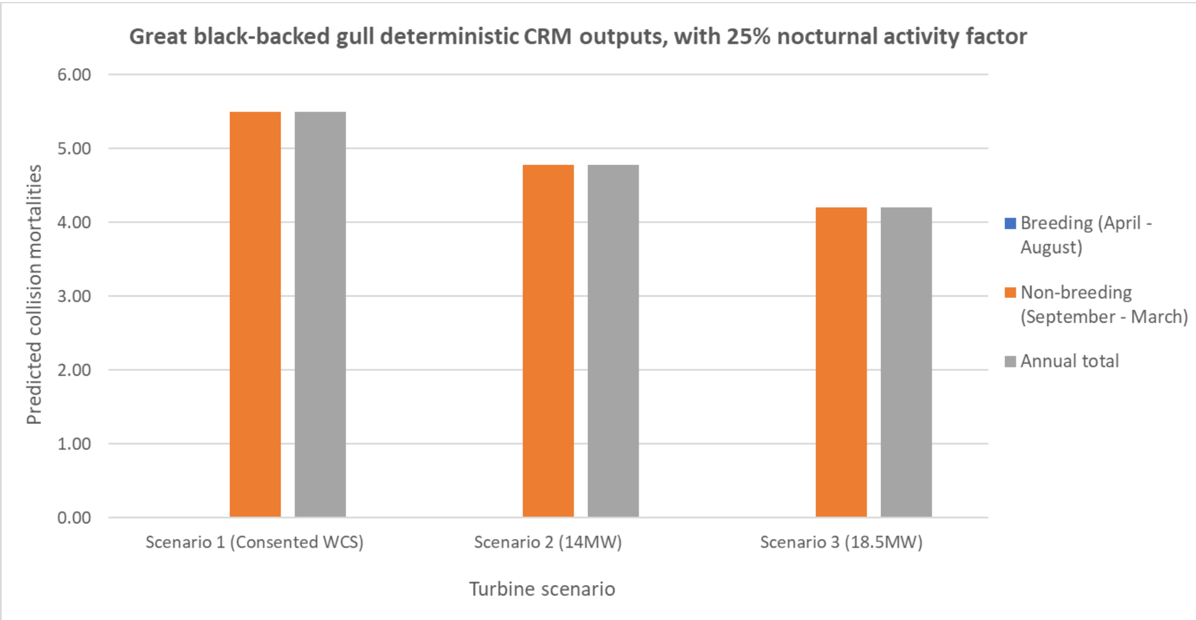

Figure 2-11 Predicted collision mortality for great black-backed gull by season and annual total, using a 25% nocturnal activity factor, modelled deterministically.

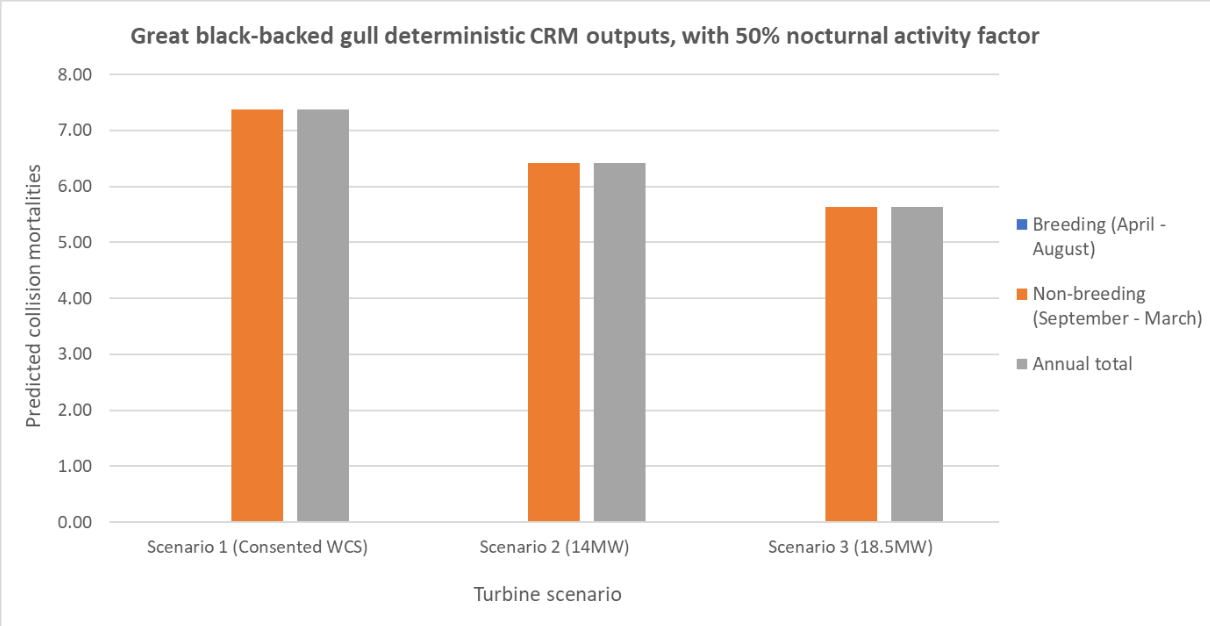

Figure 2-12 Predicted collision mortality for great black-backed gull by season and annual total, using a 50% nocturnal activity factor, modelled deterministically.

3. Discussion

For all species the new worst-case scenarios for both 14MW and 18.5MW designs predicted lower collision mortalities compared to the consented worst-case scenario (**Section 2.2**). Therefore, the design options currently under consideration by the Project would not materially change the assessment conclusions within **Green Volt Offshore Wind Farm Environmental Impact Assessment Report Chapter 12: Offshore and Intertidal Ornithology** (GVOWL, 2023b) and **Green Volt Offshore Windfarm Report to Inform Appropriate Assessment** (GVOWL, 2023c)

The lower predicted collisions for scenario 2 compared to scenario 1 (consented case) is likely to be driven predominantly by a reduction in rotor radius and rotation speed, though changes to blade width and pitch angle will have also contributed to reducing collision predictions. Generally, CRM calculates the probability of collision based on the probability of a turbine blade occupying the same space as a bird during the time it takes to pass through the rotor swept area (Masden & Cook, 2016). Therefore, a reduction in any of the above parameters would reduce the probability of collision by increasing the time and space available for a bird to transit through the array area without the risk of encountering a turbine blade.

A reduction in blade width, rotation speed and pitch would have also contributed to the lower collisions predicted for scenario 3 when compared to scenario 1 (consented case), though the predominant factor influencing the reduction in predicted collisions is the reduced maximum number of WTGs compared to scenario 1 (30 vs 35, respectively). Despite the rotor radius of scenario 3 design being larger than scenario 1 (130m compared to 121m), predicted collision risk moralities were lower. This suggests that the rotor radius has less of an impact to model outputs compared to a reduction in the maximum number of WTGs. Reducing the maximum number of the scenario 3 larger (18.5MW) WTGs reduces the total swept area of the Project which decreases the total area within the windfarm where a collision could occur. In addition, a lower number of WTGs within the same sized windfarm footprint would increase separation between WTGs which would provide wider channels within the windfarm area for seabirds to pass through.

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C Appendix – Updated Underwater Noise Modelling

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Updated Underwater Noise Modelling and Auditory Injury Ranges

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Glossary

Term	Description
Decibel	A customary scale most commonly used (in various ways) for reporting levels of sound. The actual sound measurement is compared to a fixed reference level and the "decibel" value is defined to be 10 log10(actual/reference), where (actual/reference) is a power ratio. The standard reference for underwater sound pressure is 1 micro-Pascal (µPa), and 20 micro-Pascals is the standard for airborne sound. The dB symbol is followed by a second symbol identifying the specific reference value (i.e. re 1 µPa).
Peak pressure	The highest pressure above or below ambient that is associated with a sound wave.
Permanent Threshold Shift (PTS)	A total or partial permanent loss of hearing caused by some kind of acoustic trauma. PTS results in irreversible damage to the sensory hair cells of the ear, and thus a permanent reduction of hearing acuity.
Sound Exposure Level (SEL)	The representation of a noise event if all the energy were compressed into a 1 second period. This provides a uniform way to make comparisons between noise events of different durations.
Temporary Threshold Shift (TTS)	Temporary loss of hearing as a result of exposure to sound over time. Exposure to high levels of sound over relatively short time periods will cause the same amount of TTS as exposure to lower levels of sound over longer time periods. The mechanisms underlying TTS are not well understood, but there may be some temporary damage to the sensory cells. The duration of TTS varies depending on the nature of the stimulus, but there is generally recovery of full hearing over time.

Acronyms

Term	Meaning
ADD	Acoustic Deterrent Device
HF	High Frequency
EIA	Environmental Impact Assessment
GEBCO	General Bathymetric Chart of the Oceans
JNCC	Joint Nature Conservation Committee
LF	Low Frequency
NMFS	National Marine Fisheries Service
OCA	Other Marine Carnivores in Air
OCW	Other Marine Carnivores in Water
OSP	Offshore Substation Platform
PTS	Permanent Threshold Shift
PCA	Phocid Carnivores in Air
PCW	Phocid Carnivores in Water
RL	Received Level
RMS	Root Mean Square
SEL	Sound Exposure Level
SL	Source Level
TL	Transmission Loss
TTS	Temporary Threshold Shift
VHF	Very High Frequency

Units

Unit	Description
µPa	Micro Pascal
dB	Decibel (Sound)
dB/m	Acoustic attenuation (dB/λ)
dB/rad	Attenuation per grazing angle
dB/λ	Attenuation per wavelength
Hrs	Hours
Hz	Hertz (Frequency)
kHz	Kilohertz (Frequency)
kJ	Kilojoule (Energy)
km	Kilometre (Distance)
km^2	Kilometre squared (Area)
m	*Metre (distance)*
ms	Millisecond (10^{-3} seconds) (Time)
ms^{-1} or m/s	Metres per second (Velocity)
MW	Mega Watt
Pa	Pascal (Pressure)
s	Second
T90	T90 pulse duration (i.e. the period that contains 90% of the total cumulative sound energy)

1 Introduction

In April 2024, the Marine Directorate Licensing Operations Team (MD-LOT), on behalf of Scottish Ministers, granted Green Volt Offshore Windfarm Limited (GVOWL) consent under Section 36 (s.36) of the Electricity Act 1989, Part 4 of the Marine (Scotland) Act 2010, and Part 4 of the Marine and Coastal Access Act 2009. This grants GVOWL consent to construct and operate the Green Volt Offshore Windfarm and associated offshore transmission infrastructure (the Project).

The Project is a floating offshore windfarm located approximately 80 km east of Peterhead Aberdeenshire with a Windfarm Site area of 116 km^2. The Project will have a nominal generating capacity of up to 560 MW produced by up to 35 offshore Wind Turbine Generators (WTGs) including offshore infrastructure; export cables to the Buzzard oil and gas platform complex, and export cables to landfall for connection to onshore project transmission infrastructure and the UK electricity network.

Underwater noise modelling was undertaken to support the Environmental Impact Assessment (EIA) for the Project, as set out in the Green Volt Offshore Windfarm EIA Volume 2 Technical Appendix 9.1 Underwater Noise Modelling Report (referred to as Appendix 9.1) (GVOWL, 2023). This noise modelling, undertaken by Seiche Ltd, considered potential effects of underwater noise on the marine environment from Project offshore construction activities, including potential impact piling activities required for the installation of the Project offshore substation platform (OSP) jacket foundation. Since consent for the Project was granted, some changes to the OSP jacket pile driving installation method and maximum pile dimensions have occurred. As a result, Seiche has undertaken an updated noise modelling exercise to remodel the injury ranges for relevant marine receptors (marine mammals, fish and sea turtles) associated with impact piling. The results of the remodelling exercise following the revised installation method and pile dimensions are presented in this report, and compared with the original EIA modelled results.

2 Thresholds

2.1 Marine Mammals

The auditory effects (permanent threshold shift (PTS) / temporary threshold shift (TTS)[1]) thresholds proposed by Southall *et al.* (2019) for a combination of unweighted peak pressure levels and mammal hearing weighted Sound Exposure Levels (SEL) were considered in Appendix 9.1 (GVOWL, 2023) and are considered again in the remodelling for comparison.

The auditory weighting function is designed to represent the frequency characteristics (bandwidth and amplitude) for each group within which acoustic signals can be perceived and therefore assumed to have auditory effects. The categories relevant to this study are summarised in Table 2.1.

Table 2.1: Summary of marine mammal hearing groups and associated acronyms in Southall *et al.* (2019).

Hearing group	Southall *et al.* (2019) acronym	Description
Low Frequency Cetaceans	LF	Marine mammal species such as baleen whales (e.g. minke whale *Balaenoptera acutorostrata*).
High Frequency Cetaceans	HF	Marine mammal species such as dolphins, toothed whales, beaked whales and bottlenose whales (e.g. bottlenose dolphin *Tursiops truncatus* and white-beaked dolphin *Lagenorhynchus albirostris*).
Very High Frequency Cetaceans	VHF	Marine mammal species such as true porpoises, river dolphins and pygmy/dwarf sperm whales and some oceanic dolphins, generally with auditory centre frequencies above 100 kHz) (e.g. harbour porpoise *Phocoena phocoena*).
Phocid Carnivores in Water	PCW	True seals (e.g. harbour seal *Phoca vitulina* and grey seal *Halichoerus grypus*); hearing in air is considered separately in the group Phocid Carnivores in Air (PCA).
Other Marine Carnivores in Water	OCW	Otariid pinnipeds (e.g. sea lions *Otariinae* and fur seals *Arctocephanlinae*), sea otters *Enhydra lutris* and polar bears *Ursu maritimus*; hearing in air considered separately in the group Other Marine Carnivores in Air (OCA).

The weighting functions for these groups as used in this study are shown in Figure 2-1.

[1] A full description of PTS and TTS is provided within Appendix 9.1 (GVOWL, 2023).
*Permanent Threshold Shift (**PTS**): A permanent, irreversible increase in the threshold of audibility at a specified frequency or portion of an individuals hearing range above a previously established reference level.*
*Temporary Threshold Shift (**TTS**): A temporary, reversible increase in the threshold of audibility at a specified frequency or portion of an individuals hearing range above a previously established reference level.*

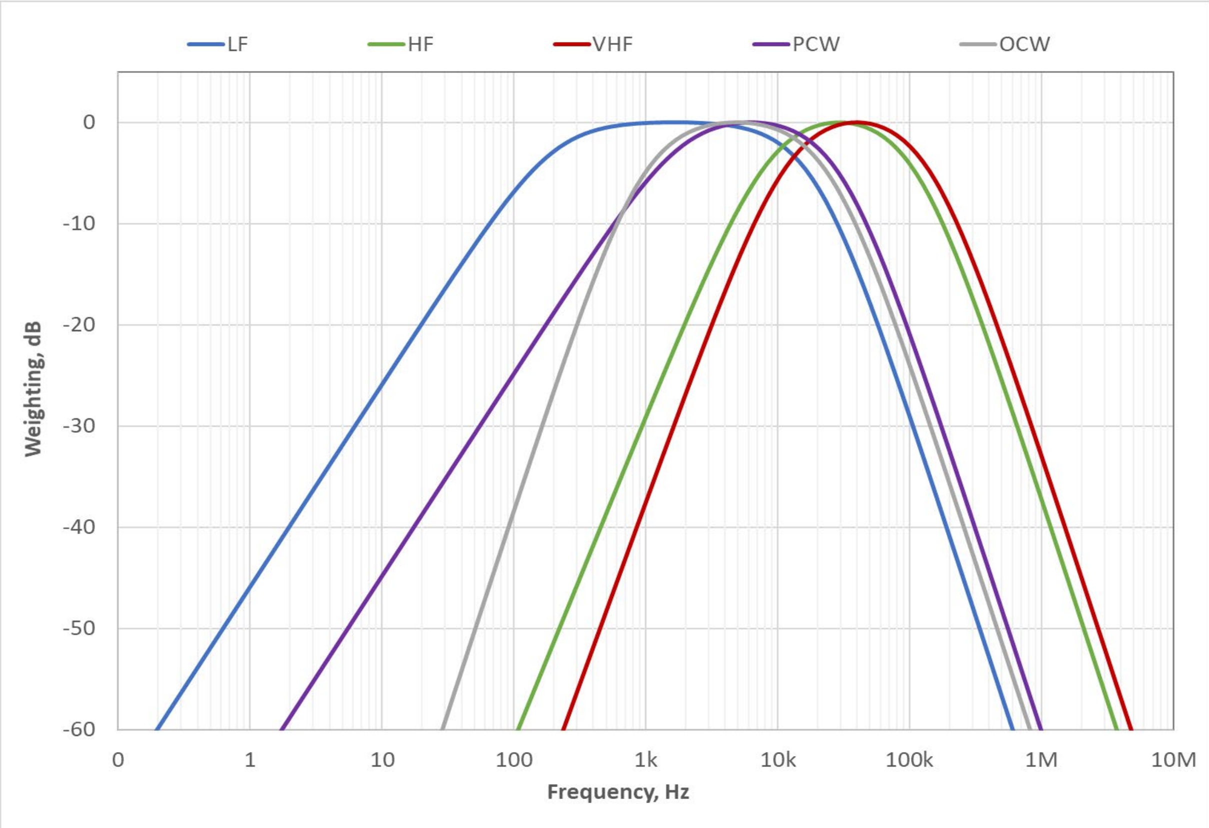

Figure 2.1: Hearing weighting functions for Pinnipeds and Cetaceans (Southall *et al*., 2019)

The PTS and TTS onset criteria proposed in Southall *et al*. (2019) are for two different types of noise as follows:

- **Impulsive sounds** which are typically transient, brief (less than one second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay (ANSI, 1986 and 2005; NIOSH, 1998). This category includes sound sources such as seismic surveys, impact (also known as percussive) piling and underwater explosions (e.g. from unexploded ordinance clearance).

- **Non-impulsive sounds** which can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent and typically do not have a high peak sound pressure with rapid rise/decay time that impulsive noises do (ANSI, 1995; NIOSH, 1998) This category includes noise sources such as continuous running machinery, sonar, and vessels.

The criteria for impulsive sounds have been adopted for this study given the nature of the noise source considered. The relevant criteria proposed by Southall *et al.* (2019) are as summarised in Table 2.2. As this study is based on the updates to piling parameters, only the impulsive thresholds are considered here.

Table 2.2: Summary of TTS and PTS thresholds for impulsive noise, according to Southall *et al.* (2019)

Hearing Group	Parameter	Southall *et al.* (2019)	
		TTS	PTS
LF cetaceans	Peak, unweighted	213	219
	SEL, LF weighted	168	183
HF cetaceans	Peak, unweighted	224	230
	SEL, HF weighted	170	185
VHF cetaceans	Peak, unweighted	196	202
	SEL, VHF weighted	140	155
PCW	Peak, unweighted	212	218
	SEL, PCW weighted	170	185

2.1.1 Behavioural disturbance

The criterion for strong behavioural disturbance is taken from the NMFS (2024) guidance, which considers marine mammals are likely to be behaviourally harassed in a manner that qualifies Level B harassment when exposed to underwater noise above $L_{P,rms}$ 160 dB re 1 µPa for impulsive sources such as impact pile driving.

2.2 Fish and Sea Turtles

Adult fish not in the immediate vicinity of the noise generating activity are generally able to vacate the area and avoid physical injury. However, larvae and eggs are not highly mobile and are therefore more likely to incur injuries from the sound energy in the immediate vicinity of the sound source, including damage to their hearing, kidneys, hearts and swim bladders. Such effects are unlikely to happen outside of the immediate vicinity of even the highest energy sound sources.

For fish, the most relevant criteria for injury are considered to be those contained in the recent Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.* 2014). These guidelines do not group by species but instead broadly group fish into the following categories based on their anatomy and the available information on hearing of other fish species with comparable anatomies:

- **Group 1 fish:** fishes with no swim bladder or other gas chamber (e.g. elasmobranchs, flatfishes and lampreys). These species are less susceptible to barotrauma and are only sensitive to particle motion, not sound pressure. Basking shark, which does not have a swim bladder, falls into this hearing group.

- **Group 2 fish:** fishes with swim bladders but the swim bladder does not play a role in hearing (e.g. salmonids). These species are susceptible to barotrauma, although hearing only involves particle motion, not sound pressure.

- **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.

- **Group 4:** Fishes that have special structures mechanically linking the swim bladder to the ear (e.g. clupeids such as herring, sprat and shads). 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.

- **Sea Turtles:** There is limited information on auditory criteria for sea turtles and the effect of impulsive noise is therefore inferred from documented effects to other vertebrates. Bone conducted hearing is the most likely mechanism for auditory reception in sea turtles and, since high frequencies are attenuated by bone, the range of hearing are limited to low frequencies only (Tonndorf, 1972). For leatherback turtle *Dermochelys coracea* the hearing range has been recorded as between 50 and 1,200 Hz with maximum sensitivity between 100 and 400 Hz (Piniak, 2012); and

- **Fish eggs and larvae**: separated due to greater vulnerability and reduced mobility. Very few peer-reviewed studies report on the response of eggs and larvae to anthropogenic sound.

The guidelines set out criteria for injury due to different sources of noise. Those relevant to the updated noise modelling are those for injury due to impulsive piling sources only. The criteria include a range of indices including SEL, rms and peak SPLs. Where insufficient data exist to determine a quantitative guideline value, the risk is 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). It should be noted that these qualitative criteria cannot differentiate between exposures to different noise levels and therefore all sources of noise, no matter how noisy, would theoretically elicit the same assessment result. However, because the qualitative risks are generally qualified as "low", with the exception of a moderate risk at "near" range (i.e. within tens of metres) for some types of animal and impairment effects, this is not considered to be a significant issue with respect to determining the potential effect of noise on fish.

The injury criteria used in this noise assessment for impulsive piling are given in Table 2.3. In the table, both peak and SEL criteria are unweighted. Physiological effects relating to injury criteria are described below (Popper *et al.*, 2014; Popper and Hawkins, 2016):

- **Mortality and potential mortal injury**: either immediate mortality or tissue and/or physiological damage that is sufficiently severe (e.g. a barotrauma) that death occurs sometime later due to decreased fitness. Mortality has a direct effect upon animal populations, especially if it affects individuals close to maturity.

- **Recoverable injury**: Tissue and other physical damage or physiological effects, that are recoverable but which may place animals at lower levels of fitness, may render them more open to predation, impaired feeding and growth, or lack of breeding success, until recovery takes place.

- **TTS**: Short term changes in hearing sensitivity may, or may not, reduce fitness and survival. Impairment of hearing may affect the ability of animals to capture prey and avoid predators, and also cause deterioration in communication between individuals; affecting growth, survival, and reproductive success. After termination of a sound that causes TTS, normal hearing ability returns over a period that is variable, depending on many factors, including the intensity and duration of sound exposure.

Table 2.3: Criteria for Onset of Injury to Fish and Sea Turtles due to Impulsive Piling (Popper *et al*., 2014)

Type of Animal	Parameter	Mortality and Potential Mortal Injury	Recoverable Injury	TTS
Group 1 Fish: no swim bladder (particle motion detection)	SEL, dB re 1 μPa^{2}s	>219	>216	>>186
	Peak, dB re 1 μPa	>213	>213	-
Group 2 Fish: where swim bladder is not involved in hearing (particle motion detection)	SEL, dB re 1 μPa^{2}s	210	203	>186
	Peak, dB re 1 μPa	>207	>207	-
Groups 3 and 4 Fish: where swim bladder is involved in hearing (primarily pressure detection)	SEL, dB re 1 μPa^{2}s	207	203	186
	Peak, dB re 1 μPa	>207	>207	-
Sea turtles	SEL, dB re 1 μPa^{2}s	210	(Near) High (Intermediate) Low (Far) Low	(Near) High (Intermediate) Low (Far) Low
	Peak, dB re 1 μPa	>207		
Eggs and larvae	SEL, dB re 1 μPa^{2}s	>210	(Near) Moderate (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Low (Far) Low
	Peak, dB re 1 μPa	>207		

Behavioural reaction of fish to sound has been found to vary between species based on their hearing sensitivity. Typically, fish sense sound via particle motion in the inner ear which is detected from sound-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 sound) can be detected by fish without swim bladders[2].

[2] *It should be noted that 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.*

Highly sensitive species such as herring have elaborate specialisations of their auditory apparatus, known as an otic bulla – a gas filled sphere, connected to the swim bladder, which enhances hearing ability. The gas filled swim bladder in species such as Atlantic cod, *Gadus morhua*, , may be involved in their hearing capabilities, so although there is no direct link to the inner ear, these species are able to detect lower sound frequencies and as such are considered to be of medium sensitivity to noise. Flat fish and elasmobranchs have no swim bladders and as such are considered to be relatively less sensitive to sound pressure.

The most recent criteria for disturbance are considered to be those contained in Popper *et al.* (2014) which set out criteria for disturbance due to different sources of noise. The risk of behavioural effects is 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 2.4.

Table 2.4: Criteria for Onset of Behavioural Effects in Fish and Sea Turtles for Impulsive and Non-Impulsive Sound (Popper *et al.*, 2014)

Type of Animal	Relative Risk of Behavioural Effects		
	Impulsive Piling	Explosives	Non-Impulsive Sound
Group 1 Fish: no swim bladder (particle motion detection)	(Near) High (Intermediate) Moderate (Far) Low	(Near) High (Intermediate) Moderate (Far) Low	(Near) Moderate (Intermediate) Moderate (Far) Low
Group 2 Fish: where swim bladder is not involved in hearing (particle motion detection)	(Near) High (Intermediate) Moderate (Far) Low	(Near) High (Intermediate) High (Far) Low	(Near) Moderate (Intermediate) Moderate (Far) Low
Groups 3 and 4 Fish: where swim bladder is involved in hearing (primarily pressure detection)	(Near) High (Intermediate) High (Far) Moderate	(Near) High (Intermediate) High (Far) Low	(Near) High (Intermediate) Moderate (Far) Low
Sea turtles	(Near) High (Intermediate) Moderate (Far) Low	(Near) High (Intermediate) High (Far) Low	(Near) High (Intermediate) Moderate (Far) Low
Eggs and larvae	(Near) Moderate (Intermediate) Low (Far) Low	(Near) High (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Moderate (Far) Low

It is important to note that the Popper *et al.* (2014) criteria for disturbance due to sound are qualitative rather than quantitative. Consequently, a source of noise of a particular type (e.g. piling) would result in the same predicted impact, no matter the level of noise produced or the propagation characteristics.

Therefore, the criteria presented in the Washington State Department of Transport Biological Assessment Preparation for Transport Projects Advanced Training Manual (WSDOT, 2011) are also used in this assessment for predicting the extent of behavioural effects due to impulsive piling. The manual suggests an un-weighted sound pressure level of 150 dB re 1 µPa (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.

3 Methodology

3.1 Background

The source modelling used in the EIA (Appendix 9.1 (GVOWL, 2023)) used the equivalent monopole Energy Conversion Factor (ECF) (De Jong and Ainslie, 2008). The assumption used for the modelling was that approximately 4.0 - 0.5% of the hammer energy is converted into sound, reducing as the pile is installed, based on a review of literature from Robinson *et al.*, 2009, Robinson *et al.*, 2013, Lepper, 2007, Lepper *et al.*, 2012, Bailey *et al.*, 2010, Lippert *et al.* (2017).

Propagation modelling for the EIA (Appendix 9.1 (GVOWL, 2023)) used the Weston Energy Flux model. This model had been widely used in other noise modelling studies for piling and was also based on the assumption of a point source.

Marine Scotland commissioned a study to look at the accuracy of ECFs (Wood *et al.*, 2023) which was published in October 2023, after the EIA noise modelling for the Project had been completed. The report concluded that there were benefits and shortcomings of the EVF method, as summarised in Table 3.1.

Table 3.1: Summary of the Benefits and Shortcomings of the ECF method as Identified by Wood et al. (2023)

Benefits	Shortcomings
Its simplicity in that it requires only the hammer energy and a value for β to generate a source function.	The ratio of hammer input energy to radiated acoustic energy in the water column is not a fixed universal value. Recorded values range from 0.17 % to 1.56 %, which equates to a range of 9.6 dB.
The speed at which one can generate source inputs and modelling outputs.	The dependence of this ratio on input parameters based on the pile, the hammer, the environment, and the geometry is not well understood.
Its exploitation of a powerful physical principle, i.e., conservation of energy	

Wood *et al.* (2023) also reviewed use of point source propagation models for piling and concluded that *"the nature of propagation from point source models is substantially different from one suitable for piling noise. It is also noted that a source level does not exist for a pile, and that it is unhelpful to attempt to characterise it as such… Predictions of distances to sound level thresholds can often be out by orders of magnitude, with examples showing errors up to 10 dB within 5 km of the pile."*

Wood *et al.* (2023) also noted that the effects of using both ECF and point source modelling methodology can be compounded when used together. The report made the following recommendations:

- Point-source equivalent ECF should not be used, having been superseded by more modern approaches.
- Numerical modelling provides the greatest flexibility in terms of selection of hammer, pile, and environment and is considered the leading method:
- Genuine values of the ECF could be used provided they are used with a model that supports them.
- Where measurements exist of similar scenarios, these may be used with adjustments to apply to alternative scenarios with caution (e.g. von Pein et al., 2022)

It is worth noting that Seiche has been using the updated von Pein *et al.* (2022) scaling method of source modelling for noise modelling studies since late 2022 and line-source noise modelling for piles since late 2023.

3.2 Updated Modelling Methodology

The steps taken in modelling the offshore pile installations using an impact hammer used an updated method from that undertaken in Appendix 9.1 (GVOWL, 2023), this included updated methods for source level (section 3.4) and sound propagation modelling (section 3.3). For the estimation of acoustic energy propagation loss at different distances from the noise source location (in different directions), the following steps were considered:

- The bathymetry of the domain around the source locations was extracted from the GEBCO database in 72 different transects.
- A geoacoustic model of the different seafloor layers in the survey region was calculated based on the British Geological Survey (BGS) borehole database and EMODnet sediment database.
- A calibrated line-source propagation model was employed to estimate the transmission loss matrices for different frequencies of interest (from 10 Hz to 80 kHz) along the 72 different transects.
- The line-source array is calibrated to match the received sound level and spectrum shape at 750 m from the pile, based on the scaling laws described by von Pein *et al.* (2022) (and in section 3.4 of this report).
- The line-source array model is used to produce frequency and range dependent received levels (RL) of acoustic energy around the chosen source position.
- The TTS and PTS potential impact distances for different marine mammal groups were calculated using relevant metrics and weighting functions (from Southall *et al.*, 2019) and by employing a simplistic animal movement model (movement directly away from the noise source at a pre-determined velocity) where appropriate.
- The recoverable injury, TTS and mortality impact distances for fish and sea turtles were calculated using relevant metrics (from Popper *et al.*, 2014) and by employing a simplistic animal movement model (movement directly away from the noise source at a pre-determined velocity) where appropriate.

For the sound exposure calculations to produce the potential marine mammal weighted SEL_{cum} impact ranges, the assumptions are the same as implemented in Appendix 9.1 (GVOWL, 2023), that a receptor (marine mammal, fish or sea turtle) will swim directly away from the sound source at the onset of activities. As an animal swims away from the sound source, the sound it is exposed to will become progressively lower (more attenuated); the cumulative SEL is derived by logarithmically adding the SEL to which the receptor is exposed as it travels away from the source. This calculation was used to estimate the approximate minimum start distance for an animal in order for it not to be exposed to sufficient acoustic energy to result in the onset of potential auditory injury or TTS. It should be noted that the sound exposure calculations are based on the simplistic assumption that the animal will continue to swim away at a constant speed. In reality the situation is more complex, and the animal is likely to move in a more complex manner: at varying speed and direction. The swim speeds used in the estimation of cumulative sound exposure for the species likely to be present in the vicinity of the Project are set out in Table 3.2, and are the same as considered in Appendix 9.1 (GVOWL, 2023).

Table 3.2: Assessment Swim Speeds of Marine Mammals and Fish that are Likely to Occur in the Vicinity of the Project, for the Purpose of Exposure Modelling

Species	Hearing group	Swim speed (m/s)	Source reference
Harbour seal, *Phoca vitulina*	Phocid Carnivores in Water (PCW)	1.8	Thompson *et al.* (2015)
Grey seal, *Halichoerus grypus*	Phocid Carnivores in Water (PCW)	1.8	Thompson *et al.* (2015)
Harbour porpoise, *Phoca vitulina*	Very High Frequency (VHF)	1.5	Otani *et al.* (2000)
Bottlenose dolphin, *Tursiops truncatus*	High Frequency (HF)	1.52	Bailey *et al.* (2010)
White-beaked dolphin, *Lagenorhynchus albirostris*	High Frequency (HF)	1.52	Bailey *et al.* (2010)
Minke whale, *Balaenoptera acutorostrata*	Low Frequency (LF)	2.3	Boisseau *et al.* (2021)
Basking Shark, *Cetorhinus maximus*	Group 1 Fish	1.0	Sims (2000)
All other fish groups	All fish groups	0.5	Popper *et al.* (2014)

The level of detail presented in terms of noise modelling needs to be considered in relation to the level of uncertainty for animal injury and disturbance thresholds. Uncertainty in the noise level predictions will be higher over larger propagation distances (i.e. in relation to disturbance thresholds) and much lower over shorter distances (i.e. in relation to injury thresholds). Nevertheless, it is considered that the uncertainty in animal injury and disturbance thresholds is likely to be higher than uncertainty in noise predictions. This is further compounded by differences in individual animal response, sensitivity, and behaviour. It would therefore be wholly misleading to present any injury or disturbance ranges as a clear line beyond which no effect can occur, and it would be equally misleading to present any noise modelling results in such a way.

3.3 Updated Sound Propagation Modelling Method

In the case of offshore pile installation using an impact hammer, the sound source can be thought of as a "line source" extending through the water column (or in the case of installations using a submersible hammer, a line source through a lower portion of the water column). The hammer strike at the top of the pile produces a compression wave in the pile resulting in radial displacement of the pile walls which is transmitted into the surrounding media (water and sediments) as sound waves. These compressional waves travel through the pile at circa 5,000 m/s, resulting in a conically shaped wavefront.

Underwater acoustic propagation modelling for this Project was undertaken using a combined distributed line-source array normal mode model for low frequencies (<1 kHz) complimented by a line-source energy flux model for high frequencies (>1 kHz). The line source normal mode model is based on the KrakenC solver (Porter 2001) implemented for a line array over the pile length. The directive line-source energy flux model is based on an implementation of the energy flux model for a directional source set out in de Jong *et al.* (2019).

The normal-mode method involves solving a depth-dependent equation based on the assumption of a set of modes of vibration which are roughly akin to the modes of a vibrating string (Jensen, 1994). The complete acoustic field is constructed by summing up contributions of each of the modes weighted in accordance with the source depth. The KrakenC solver finds the normal modes in the complex wavenumber plane, which allows it to deal with elastic seabed layers, and to include the effects of leaky modes, making it a good choice for calculation of low frequencies for both close and long range noise fields. The method is, however, slow at higher frequencies and has therefore only been implemented for low frequencies (<1 kHz).

The line-source energy flux model (de Jong *et al.* 2019) used for higher frequencies includes the effect of directionality of the cone shaped wavefront associated with piling noise (circa 17 degrees). This results in damped cylindrical spreading at shorter ranges and mode stripping behaviour at more distant ranges. At even more distant ranges, once the 'mode stripping' has eliminated the contribution of all waveguide modes except the lowest mode, propagation is evaluated according to a single mode regime.

3.3.1 Seiche Line Source Model Calibration

The Seiche Ltd line array model has been benchmarked against the COMPILE benchmark workshop for numerical models for pile driving acoustics (Lippert *et al.*, 2016). The COMPILE workshop included modelling results from a number of different organisations in an attempt to compare the performance of acoustic models for piling against pre-defined input parameters. The models included in the benchmarking exercise included those developed by Seoul National University (SNU), Netherlands Organisation for Applied Scientific Research (TNO), Hamburg University of Technology (TUHH), Jasco Applied Sciences, Curtin University and Bundeswehr Technical Centre for Ships and Naval Weapons, Maritime Technology and Research (WTD 71).

A comparison between the Seiche model and the benchmark workshop model results is presented in Figure 3.1. The results of the benchmarking exercise show good correlation with the other models with the results most closely matching the TNO model. The Seiche model predicts slightly higher received levels compared to the other models at 20 km range for this particular benchmark scenario (10 m water depth, sand substrate). Nevertheless, it is considered that the results of the benchmarking exercise demonstrate a good degree of agreement with other noise propagation models for piling.

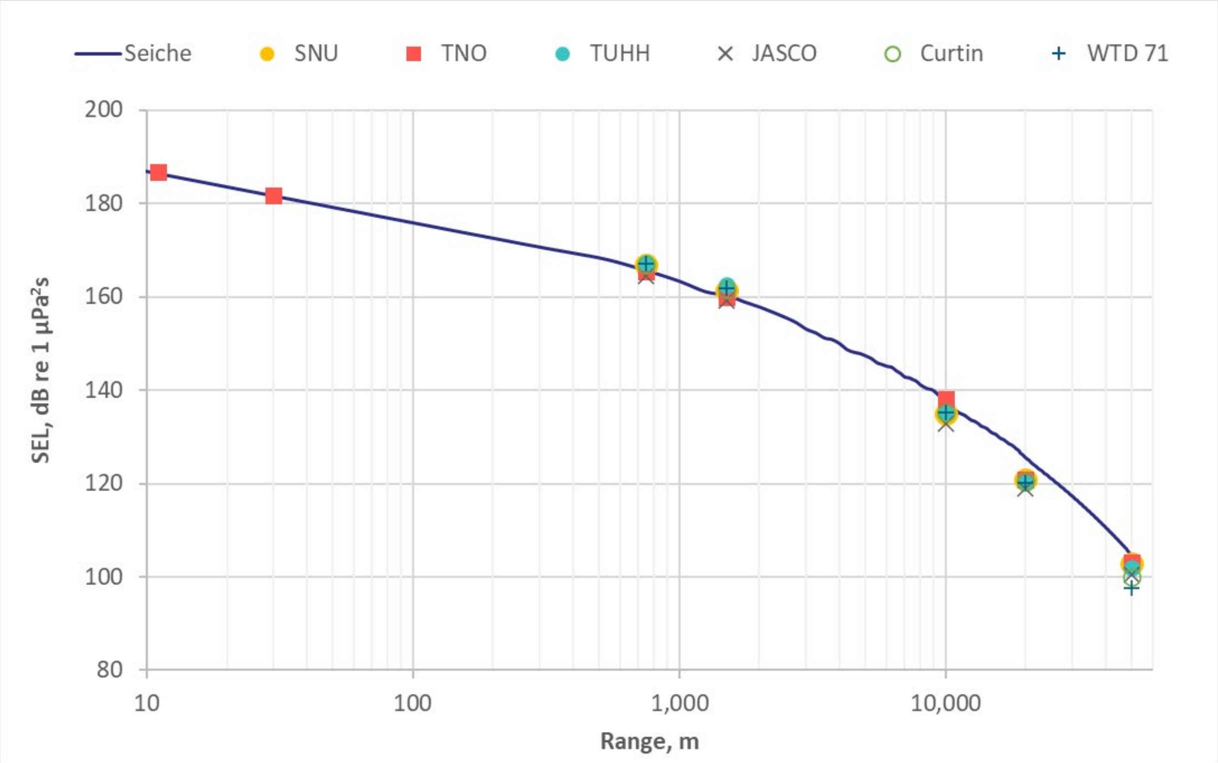

Figure 3.1: Comparison of Seiche Underwater Acoustic Model Against COMPILE Benchmarks

3.4 Revised Source Modelling Method

Source levels were determined by scaling data measured during pile driving for similar operations to the Project in order to determine source levels. The subject of noise generation due to impact piling is an active area of research and the evidence base is constantly being updated by new measurements, research and published papers. A recent peer-reviewed paper (von Pein *et al.*, 2022) presents a methodology for the dependencies of the SEL on strike energy, diameter, ram weight, and water depth that can be used for scaling measured or computed SELs from one project to another. The method has been shown to be usable within practical ranges of accuracy, especially if the measurement uncertainties are taken into account. The paper suggests that scaling should be performed over either a small number of very similar piling situations or over a larger data set with according averaging. This is a recently published method for deriving the noise source level which provides a more scientifically robust method compared to using an energy conversion factor (the conversion factor method simply assumes that a percentage of the hammer energy is converted into noise irrespective of parameters such as pile size, water depth and hammer specifications).

Since the von Pein *et al*. (2022) methodology takes into account several site-specific and pile-specific factors, in addition to hammer energy, and because it is based on a scientifically rigorous and peer reviewed study, it is considered to be a significant improvement on the use of energy conversion factors.

Using the equation below (von Pein *et al.*, 2022), a broadband source level value is calculated for the noise emitted during impact pile driving operation in each operation window.

$$SEL_1 = SEL_0 + 10log_{10}\left(\frac{E_1}{E_0}\right) + 16.7log_{10}\left(\frac{d_1}{d_0}\right) - 10log_{10}\left(\frac{m_{r,1}}{m_{r,0}}\right) + 750\left[\frac{10log_{10}(|R_0|^2)}{2\,cot(\varphi)}\left(\frac{1}{h_1} - \frac{1}{h_0}\right)\right]$$

In this equation, *E* is the hammer energy employed in Joules, *d* is the pile diameter, m_r is the ram mass in kg, *h* is the water depth in m, $|R_0|$ is the reflection coefficient and φ is the propagation angle (approximately 17° for a Mach wave[3] generated by impact piling). The equation allows measured pile noise data from one site (denoted by subscript 0) to be scaled to another site (denoted by subscript 1).

The spectral distribution of the source SELs for impact piling were derived from the reference spectrum provided in the ORJIP ReCon report, reproduced in Figure 3.2.

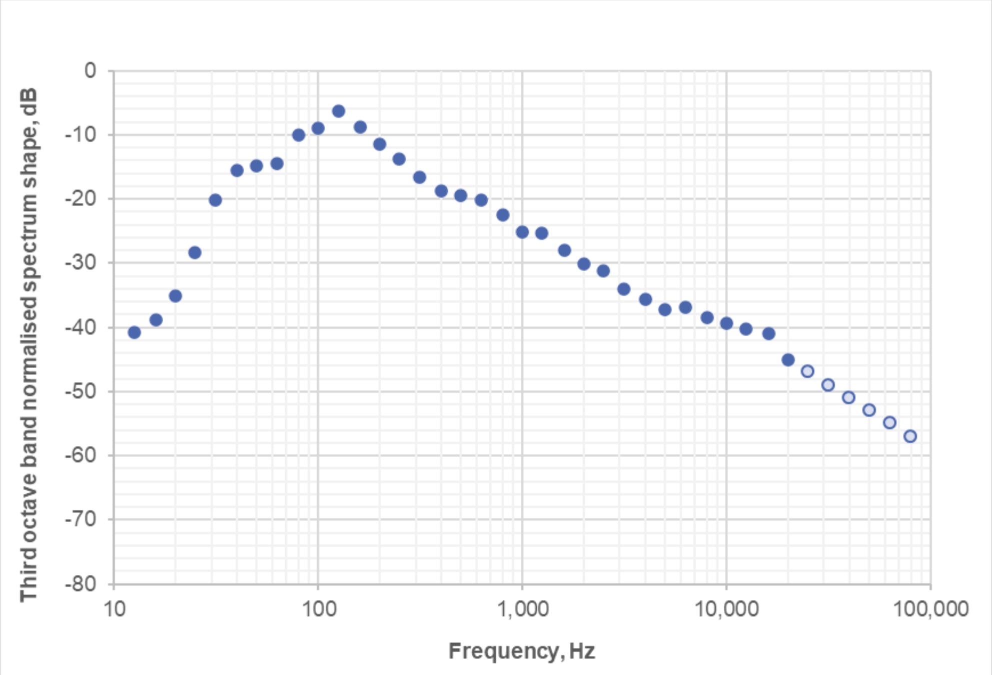

Figure 3.2: Normalised median 1/3 octave spectra for monopile installations used in the source level modelling.

[3] *In acoustics, a Mach wave is a type of shock wave generated when a source moves through a medium at a speed exceeding the speed of sound. In the context of underwater piling, Mach waves can be produced when stress waves travel down the pile (from the site of the hammer strike / anvil) causing coherent, angled wavefronts to radiate into the surrounding water.*

4 Pile Installation Method

The purpose of the remodelling exercise is to consider the impact of the updates to the changes to the OSP jacket pile driving installation method and maximum pile dimensions on the modelled injury ranges for marine mammals, fish and sea turtles. The original installation method and dimensions used in Appendix 9.1, GVOWL (2023) are below in Table 4.1, and the updated in Table 4.2. All other parameters, including, but not limited to, modelled location, water depth, seafloor geology etc., are unchanged from the previous assessment and are as described in Appendix 9.1, GVOWL (2023).

Table 4.1: Original OSP installation method and maximum pile dimensions.

	Duration, minutes	Hammer Energy, kJ	Strike Rate (strikes per minute)	Number of strikes
ADD	15	N/A	N/A	N/A
Initiation	1	300	6	6
Soft start	20	500	40	800
Ramp up	40	500 – 1,200	40	1,600
	80	1,200 – 2,000	40	3,200
Full power piling	120	2,000 – 2,300	40	4,800
Maximum rated hammer energy, kJ	2,300			
Pile diameter, m	3.0			
Final Pile penetration	50			

Table 4.2: Updated OSP installation method and maximum pile dimensions.

	Duration, minutes	Hammer Energy, kJ	Strike Rate (strikes per minute)	Number of strikes
ADD	15	N/A	N/A	N/A
Initiation	1	300	6	6
Soft start	20	500	40	800
Ramp up	30	500 - 1,500	40	1,200
	40	1,500 - 2,500	40	1,600
Full power piling	120	2,500 - 3,500	40	4,800
Maximum rated hammer energy, kJ	3,500			
Pile diameter, m	3.1			
Final Pile penetration	75			

Additional to these updates to the installation method and dimensions, is the proposal of consecutive pile installations, with the installation of up to four piles possible in a 24-hour period.

5 Results

5.1 Updated results

Modelling results are presented both with and without the use of 15 minutes of ADD prior to installation. The injury ranges for peak sound pressure are based on the noise from the maximum hammer energy over the entire installation as well as the first hammer strike.

During impact piling the interaction with the seabed and the water column is complex. In these cases, a combination of dispersion (i.e. where the waveform shape elongates), and multiple reflections from the sea surface and bottom and molecular absorption of high frequency energy, the noise will lose its impulsive shape after some distance (generally in order of several kilometres). This acoustic wave elongation effect is particularly pronounced at larger ranges of several kilometres and, in particular, it is considered highly unlikely that predicted PTS or TTS ranges for impulsive noise which are found to be in the tens of kilometres are realistic (Southall, 2021).

Consequently, great caution should be used when interpreting any results with predicted injury ranges in the order of tens of kilometres. This is discussed further in section 5.2.

The Southall et al. (2019) marine mammal weighted cumulative SEL and peak Lp,0-pk injury and TTS ranges are presented in Table 5.1 and Table 5.2.

Table 5.1: Injury and disturbance ranges based on the cumulative SEL metric for marine mammals due to impact pile driving of a single substation jacket pile, with and without the use of an ADD (N/E = threshold not exceeded).

Species/Group	Threshold (Weighted SEL dB re 1 µPa²s)	Range (m)	
		Without ADD	With 15 mins ADD
LF	PTS – 183	3,059	958
	TTS – 168	65,587*	64,170*
HF	PTS – 185	N/E	N/E
	TTS – 170	18	N/E
VHF	PTS – 155	520	N/E
	TTS – 140	6,432	5,082
PCW	PTS – 185	N/E	N/E
	TTS – 170	3,045	1,411
Marine mammals	Strong Behavioural Disturbance – $L_{P,rms}$ 160 dB re 1 µPa	17,770	

** PTS or TTS ranges in the tens of kilometres are likely to be a significantly over-precautionary estimate since impulsive sound will transition to be non-impulsive at these ranges.*

Table 5.2: Summary of peak pressure injury ranges for marine mammals due to the phase of impact piling resulting in the maximum peak sound pressure level, and due to the first hammer strike.

Species/Group	Threshold ($L_{P,pk}$, dB re 1 µPa)	Range (m)	
		Max Peak	First Hammer Strike
LF	PTS - 219	431	82
	TTS - 213	639	134
HF	PTS - 230	117	33
	TTS - 224	195	54
VHF	PTS - 202	1,966	579
	TTS - 196	2,839	621
PCW	PTS - 218	139	90
	TTS - 212	752	150

The results of the noise modelling for fish and sea turtles are shown in Table 5.3, based on the cumulative sound exposure level thresholds, and in Table 5.4 based on the peak sound pressure thresholds. The tables show two results for Group 1 Fish, one based on the 0.5 m/s swim speeds, and another (in square brackets) showing the range for basking sharks using a higher swim speed of 1 m/s. Similarly, sea turtles have been assumed to swim at a speed of 0.5 m/s whereas fish eggs and larvae have been assumed to be static, resulting in a different impact range for the same SEL threshold.

Table 5.3: Injury ranges for fish based on the cumulative SEL metric due to impact pile driving of a single jacket pile based on the cumulative SEL metric (N/E = threshold not exceeded)

Hearing Group	Response	Threshold (SEL, dB re 1 µPa²s)	Range (m)
Group 1 Fish: No swim bladder (particle motion detection) – [basking shark ranges shown in square brackets].	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	12,588 [10,079]*
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	210	11
	Recoverable injury	203	883
	TTS	186	12,588*
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality	207	94
	Recoverable injury	203	883
	TTS	186	12,588*
Sea turtles	Mortality	210	11
Fish eggs and larvae (static)	Mortality	210	830
All	Behavioural disturbance	150 dB re 1 µPa (rms)	56,451
** TTS ranges in the tens of kilometres are likely to be a significantly over-precautionary estimate since impulsive sound will transition to be non-impulsive at these ranges.*			

Table 5.4: Summary of peak pressure injury ranges for fish due to the phase of impact piling resulting in the maximum peak sound pressure level, and due to the first hammer strike.

Hearing Group	Response	Threshold ($L_{p,0-pk}$, dB re 1 µPa)	Range (m)	
			Max Peak	First Hammer Strike
Group 1 Fish: No swim bladder (particle motion detection) and basking sharks	Mortality	213	639	134
	Recoverable injury	213	639	134
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	207	1,000	477
	Recoverable injury	207	1,000	477
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality	207	1,000	477
	Recoverable injury	207	1,000	477
Sea turtles	Mortality	207	1,000	477
Fish eggs and larvae (static)	Mortality	207	1,000	477

5.1.1 Consecutive Piling

There is a potential during construction for the installation of up to four piles consecutively during a single 24hour period. The potential cumulative SEL injury ranges for marine mammals and fish due to impact pile driving of piles are modelled as following the same piling schedules with phases occurring consecutively. It is assumed that the sequential piles are installed directly one following another with no break in the piling.

Distances are presented at which sound levels decrease to below PTS/TTS threshold values in terms of cumulative SEL.

Table 5.5: Potential marine mammal injury ranges for consecutive pile installation of pin piles, based on the Southall *et al*. (2019) cumulative SEL metric (N/E - threshold not exceeded)

Species/Group	Threshold (Weighted SEL dB re 1 µPa²s)	Range (m)	
		Without ADD	With 15 mins ADD
LF	PTS – 183	4,611	2,529
	TTS – 168	> 65 km *	> 65 km *
HF	PTS – 185	N/E	N/E
	TTS – 170	17	N/E
VHF	PTS – 155	527	N/E
	TTS – 140	7,221	5,870
PCW	PTS – 185	5	N/E
	TTS – 170	4,675	3,051

** PTS or TTS ranges in the tens of kilometres are likely to be a significantly over-precautionary estimate since impulsive sound will transition to be non-impulsive at these ranges.*

Table 5.6: Potential fish and sea turtle injury ranges for consecutive pile installation of pin piles, based on Popper *et al*. (2014) cumulative SEL metric (N/E - threshold not exceeded).

Hearing Group	Response	Threshold (SEL, dB re 1 µPa²s)	Range (m)
Group 1 Fish: No swim bladder (particle motion detection) – [basking shark ranges shown in square brackets].	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	24,257 [17,051] *
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	210	10
	Recoverable injury	203	845
	TTS	186	24,257 *
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality	207	107
	Recoverable injury	203	845
	TTS	186	24,257 *
Sea turtles	Mortality	210	10
Fish eggs and larvae (static)	Mortality	210	2,007
All	Behavioural disturbance	150 dB re 1 µPa (rms)	56,451 *
** TTS ranges in the tens of kilometres are likely to be a significantly over-precautionary estimate since impulsive sound will transition to be non-impulsive at these ranges.*			

5.2 Use of Impulsive Noise Thresholds at Large Ranges

For any noise of a given amplitude and frequency content, impulsive noise has a greater potential to cause auditory injury than a similar magnitude non-impulsive noise (Southall *et al*., 2007; 2019; 2021; NMFS, 2018; von Benda-Beckmann *et al*., 2022). For highly impulsive noises such as those generated by impact piling, the interaction with the seafloor and the water column is complex.

An article by Southall (2021) discusses this aspect in detail, and notes that "*…when onset criteria levels were applied to relatively high-intensity impulsive sources (e.g. pile driving), TTS onset was predicted in some instances at ranges of tens of kilometres from the sources. In reality, acoustic propagation over such ranges transforms impulsive characteristics in time and frequency (see Hastie et al. 2019; Amaral et al. 2020; Martin et al., 2020). Changes to received signals include less rapid signal onset, longer total duration, reduced crest factor, reduced kurtosis, and narrower bandwidth (reduced high-frequency content). A better means of accounting for these changes can avoid overly precautionary conclusions, although how to do so is proving vexing*". The point is reinforced later in the discussion which points out that "…*it should be recognised that the use of impulsive exposure criteria for receivers at greater ranges (tens of kilometres) is almost certainly an overly precautionary interpretation of existing criteria*".

This acoustic wave elongation effect is particularly pronounced at larger ranges of several kilometres and, in particular, it is considered highly unlikely that predicted PTS or TTS ranges for impulsive noise which are found to be in the tens of kilometres are realistic (Southall, 2021). However, the precise range at which the transition from impulsive to non-impulsive noise occurs is difficult to define precisely, not least because the transition also depends on the response of the marine mammal or fish ear. Consequently, there is currently no consensus as to the range at which this transition occurs or indeed the measure of impulsivity which can be used to determine which threshold should be applied (Southall, 2021). However, evidence for impact pile driving and seismic source arrays does indicate that some measures of impulsivity change markedly within 10 km of the source (Hastie *et al.*, 2019). Additionally, the draft NMFS (2018) guidance suggested 3 km as a transition range, but this was removed from the final document.

The cross-over between impulsive and non-impulsive noise is an area of ongoing research and there are a number of potential methods for determining the cross-over point being investigated, such as the kurtosis metric, and the loss of high frequency energy from the spectrum (above 10 kHz, e.g. Southall, 2021). In the meantime, it is considered that any predicted injury ranges in the tens of kilometres are almost certainly an overly precautionary interpretation of existing criteria (Southall, 2021).

As disturbance ranges are likely to extend beyond the range at which injury (PTS or TTS) could occur, this transition from impulsive to continuous noise is likely to have even more impact on the disturbance range (e.g. Southall *et al.*, 2021). For example, where dose-response relationships have been derived based on exposure to impulsive noises, particularly where these have been derived based on experiments relatively close to the impulsive source, then extrapolation of the dose-response relationship to larger ranges could be misleading. This is particularly true where the dose-response relationship has been derived using parameters such as unweighted single pulse SEL or $rms_{(T90)}$ SPL, which does not take into account the characteristics (e.g. frequency content of impulsivity) of the noise. Consequently, great caution should be used when interpreting potential disturbance ranges in the order of tens of kilometres. Where appropriate, these should be considered alongside an understanding of potential background noise levels in order to understand the distances at which noises related to an impulsive source may be detected.

5.3 Comparison of results

The tables set out in this section contain a comparison of the cumulative SEL and $L_{P,pk}$ injury ranges presented in this report for the updated installation method and pile dimensions, with those equivalent injury ranges modelled in Appendix 9.1 (GVOWL, 2023), for the original installation method and pile dimensions. These results are presented for the installation of a single pile.

The SEL_{cum} ranges for marine mammals are set out in Table 5.7, with Southall *et al.* (2019) weightings and thresholds, with and without the use of ADD as a mitigation measure, and for fish in Table 5.9.

The $L_{P,pk}$ ranges for marine mammals are set out in Table 5.8 and for fish in Table 5.10.

Table 5.7: Summary of comparisons of SEL_{cum} injury ranges between the original installation method and pile dimensions, and for the updated installation method and pile dimensions for marine mammals.

Species/Group	Threshold (Weighted SEL, dB re 1 µPa²s)	Pile Parameters	Range (m)	
			Without ADD	With 15 mins ADD
LF	PTS – 183	Updated	3,059	958
		Original	1,085	N/E
	TTS – 168	Updated	65,587*	64,170*
		Original	41,900*	39,800*
HF	PTS – 185	Updated	N/E	N/E
		Original	N/E	N/E
	TTS – 170	Updated	18	N/E
		Original	N/E	N/E
VHF	PTS – 155	Updated	520	N/E
		Original	227	N/E
	TTS – 140	Updated	6,432	5,082
		Original	3,580	2,190
PCW	PTS – 185	Updated	N/E	N/E
		Original	N/E	N/E
	TTS – 170	Updated	3,045	1,411
		Original	1,245	N/E

** PTS or TTS ranges in the tens of kilometres are likely to be a significantly over-precautionary estimate since impulsive sound will transition to be non-impulsive at these ranges.*

Table 5.8: Summary of comparisons of $L_{p,0\text{-}pk}$ injury ranges between the original and updated installation method and pile dimensions for marine mammals.

Species/Group	Threshold ($L_{p,0\text{-}pk}$, dB re 1 µPa)	Pile Parameters	Range (m)	
			First Hammer Strike	Max Peak
LF	PTS – 219	Updated	82	431
		Original	49	35
	TTS – 213	Updated	134	639
		Original	85	62
HF	PTS – 230	Updated	33	117
		Original	18	13
	TTS – 224	Updated	54	195
		Original	31	22
VHF	PTS – 202	Updated	579	1,966
		Original	234	170
	TTS – 196	Updated	621	2,839
		Original	407	295
PCW	PTS – 218	Updated	90	139
		Original	54	39
	TTS – 212	Updated	150	752
		Original	93	68

Table 5.9: Summary of comparison for SEL_{cum} injury ranges for fish between the updated installation method and pile dimensions and the original installation method and pile dimensions.

Hearing Group	Response	Threshold (SEL, dB re 1 µPa²s)	Pile Parameters	Range (m)
Group 1 Fish: No swim bladder (particle motion detection) – [basking shark ranges shown in square brackets].	Mortality	219	Updated	N/E
			Original	N/E
	Recoverable injury	216	Updated	N/E
			Original	N/E
	TTS	186	Updated	12,588 [10,079]*
			Original	4,500 [2,550]
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	210	Updated	11
			Original	N/E
	Recoverable injury	203	Updated	883
			Original	N/E
	TTS	186	Updated	12,588*
			Original	4,500
	Mortality	207	Updated	94

Hearing Group	Response	Threshold (SEL, dB re 1 µPa²s)	Pile Parameters	Range (m)
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)			Original	N/E
	Recoverable injury	203	Updated	883
			Original	N/E
	TTS	186	Updated	12,588*
			Original	4,500
Sea turtles	Mortality	210	Updated	11
			Original	N/E
Fish eggs and larvae (static)	Mortality	210	Updated	830
			Original	329
All	Behavioural disturbance	150 dB re 1 µPa (rms)	Updated	56 km**
			Original	13 km

** TTS ranges in the tens of kilometres are likely to be a significantly over-precautionary estimate since impulsive sound will transition to be non-impulsive at these ranges.*

***It should be noted that the rms sound pressure levels are based on the assumption of a pulse T90 time of 100 ms. However, measurement data shows that in reality the pulse length increases with increasing distance to approximately 250 ms at 15 km and will increase further beyond this range. Consequently, the estimates of range at which the 150 dB rms threshold is exceeded will be significantly overestimated for larger ranges due to the assumption of a 100 ms T90.*

Table 5.10: Summary of comparisons of $L_{P,pk}$ injury ranges between the original and updated installation method and pile dimensions for fish.

Hearing Group	Response	Threshold (SEL, dB re 1 µPa²s)	Pile Parameters	Range (m)	
				First Hammer Strike	Max peak
Group 1 Fish: No swim bladder (particle motion detection) – [basking shark ranges shown in square brackets].	Mortality	213	Updated	134	639
			Original	62	85
	Recoverable injury	213	Updated	134	639
			Original	62	85
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	207	Updated	477	1,000
			Original	107	147
	Recoverable injury	207	Updated	477	1,000
			Original	107	147
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality	207	Updated	477	1,000
			Original	107	147
	Recoverable injury	207	Updated	477	1,000
			Original	107	147
Sea turtles	Mortality	207	Updated	477	1,000
			Original	107	147
Fish eggs and larvae (static)	Mortality	207	Updated	477	1,000
			Original	107	147

6 Discussion

The comparison between the original and updated pile installation method and pile dimensions, and the related injury ranges shows a marginal increase in ranges, with most of the weighted SEL_{cum} ranges remain not exceeded with the use of 15 minutes of ADD for the installation of a single pile.

For marine mammals, the LF weighted PTS range is 958 m with 15 minutes of ADD, and the only PTS range not reduced to not exceeded with the use of ADD. The LF and VHF cetaceans TTS ranges are still exceeded with the use of ADD, however this was the case in the previous piling scenario as presented in Appendix 9.1, (GVOWL, 2023). The PCW TTS range is 1,411 m with ADD, while this was not exceeded in the previous scenario.

For fish the TTS range increased from 4,500 m to 12,588 m and from 2,550 m to 10,079 m for basking sharks. In terms of the SEL_{cum} metric, for group 2 fish the mortality range is 11 m and the recoverable injury range is 883 m, while these were previously not exceeded in the original modelling set out in Appendix 9.1 (GVOWL, 2023). For group 3 and 4 fish the mortality range is 94 m and recoverable injury is 883 m, where these were not exceeded previously in the original modelling. The sea turtle mortality range has increased to 11 m and to 830 m for fish eggs and larvae.

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