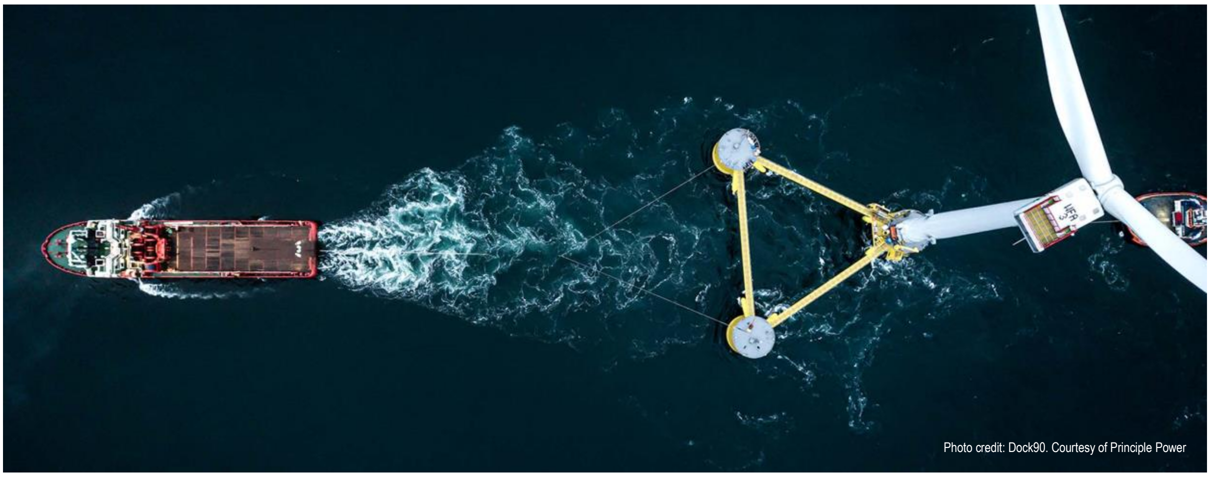

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Project Erebus: Supplementary Environmental Information Addendum Report

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Document History

Rev	Date	Authored	Reviewed	Approved	Modifications
01	2022-08-23	L. Lawrie	D. Lloyd Jones	B. Huskinson S. Evans	[Add list of modifications]

Contents

Chapter 1 Introduction

1.1 Request for Further Information

1.1.1.1 This report has been produced in response to Natural Resources Wales (NRW) Marine Licensing's request, email dated 29 June 2022, for further information under the Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended) for Marine Licence application ORML2170 Project Erebus. The Project is a demonstration scale Floating Offshore Wind (FLOW) development in the Celtic Sea region, proposed by the developer, Blue Gem Wind (BGW), a joint venture between Simply Blue Energy (SBE) and TotalEnergies.

1.1.1.2 The application for consent under Section 36 of the Electricity Act 1989 (and deemed planning consent under the Town and Country Planning Act 1990) and application for a marine licence under Part 4 of the Marine and Coastal Access Act 2009 were submitted in December 2021. Public notices were issued for both applications, and a period of statutory public consultation followed, which was extended to 22 April 2022.

1.1.1.3 NRW Marine Licensing's initial review is that further information is required to properly consider and come to a conclusion on the likely significant effects of the Project, and inform its final decision. These clarifications were summarised in a letter, dated 29 June 2022, and presented in detail via the ORML2170 Technical and General Consultation Responses spreadsheet.

1.1.1.4 As agreed with NRW Marine Licensing (email dated 19 July 2022), responses to consultee comments have been made directly into the spreadsheet, unless additional information is required, in which case it has been presented in this Supplementary Environmental Information (SEI) Addendum report. Where information is presented in this report, the relevant section has been cross referenced in the spreadsheet.

1.1.1.5 To accompany the SEI Addendum report and spreadsheet, the following documents have also been submitted:

- Response to Planning and Environment Decision Wales (PEDW), dated 08 July 2022; and
- Draft Outline Environmental Monitoring Plan (OEMP).

1.2 Technical Group Meetings and Consultation

1.2.1.1 Following the period of statutory and public consultation, PEDW and NRW Marine Licensing shared consultation responses received for both the S.36 and Marine Licence applications. In response to these, technical group meetings were arranged with the Statutory Nature Conservation Bodies (SNCBs), NRW Advisory, and the Joint Nature Conservation Committee (JNCC). An initial clarification call, held on 25 May 2022, was arranged to discuss the range of comments received and understand the key issues in respect of coastal processes, benthic ecology, offshore ornithology, and marine mammals. These topics were judged to have the most significant issues requiring resolution.

1.2.1.2 Specific actions to address concerns relating to coastal processes and benthic ecology were agreed during the call, including additional sediment plume modelling and further assessment of selected benthic ecology receptors.

1.2.1.3 Subsequent calls were required to agree actions for marine mammals and ornithology. These were held on 22 June and 28 June 2022, respectively. Ahead of these calls, Technical Notes were circulated for both topics, setting out the Applicant's understanding of the key issues raised by the SNCBs, and key stakeholders and proposing actions to address outstanding concerns. Key actions required to progress the resolution of outstanding concerns were agreed during the meeting, and form the basis of this SEI.

1.2.1.4 Upon receipt of NRW Marine Licensing's final response, the Royal Society for the Protection for Birds (RSPB) and The Wildlife Trust of South and West Wales were invited to meet, and discuss their comments. A meeting with The Wildlife Trust of South and West Wales has had to be rescheduled due to availability, but is arranged to discuss their concerns, and update on progress to address specific ornithological issues. No reply was received from the RSPB in response to the meeting invitation.

1.3 Next Steps

1.3.1.1 The Applicant confirms that they have met with the relevant stakeholders to discuss and address all significant matters raised in submission. It is therefore their contention that all outstanding queries and clarifications have been addressed via the SEI Addendum and spreadsheet.

1.3.1.2 The Applicant, where appropriate to do so, commits to providing further information on design and construction methodology, along with further developed mitigation and monitoring proposals post consent. This will be via discharge of marine licence conditions and planning conditions and the S.36 application. These conditions shall be discharged prior to the commencement of works or during the operational and decommissioning phases.

1.3.1.3 Project Erebus, as a test and demonstration scale Project, has been developed on the basis of a 12-month determination period to allow the Project to progress under the 2023 Contracts for Difference (CfD) round. The Applicant will continue to work closely with NRW Marine Licensing and PEDW, on behalf of the Welsh Ministers, to achieve all necessary consents to meet the CfD deadline.

Chapter 2 Marine and Coastal Processes

2.1 Introduction

2.1.1.1 This technical report provides supplementary environmental information and additional detailed responses to specific queries raised by NRW Advisory via their formal consultation response to the Project Environmental Statement (ES). The ES was submitted to relevant bodies in December 2021, alongside applications for a Marine Licence and Section 36 consent. The key points raised by NRW Advisory in their response related to the following:

- The potential impact of fine sediment plumes from cable installation/landfall works on Maerl Beds in Milford Haven;
- The potential impact of external cable protection on sediment transport affecting Turbot Bank; and
- Rates of bedform recovery following localised levelling disturbance, potentially required prior to cable installation works.

2.1.1.2 The findings and conclusions of this report are consistent with the assessments previously presented in both Volume 1 Chapter 6: Marine and Coastal Processes, and Volume 3 Technical Appendix 6.1 of the Project ES. These were used to inform assessments for other EIA receptor groups, which may potentially be sensitive to changes in suspended sediment concentration (SSC) and deposition. No changes to the conclusions of the Project ES documents above are suggested.

2.1.1.3 In most cases, marine and coastal processes are not, in themselves, receptors but are, instead, 'pathways' which have the potential to indirectly impact other environmental receptors. For example, changes to SSC and associated sediment deposition are considered in the marine and coastal processes topic as potential pathways of change, that are then assessed by other EIA topics in relation to other sensitive receptors, i.e. benthic habitats. The marine and coastal processes study area is shown in Figure 2-1.

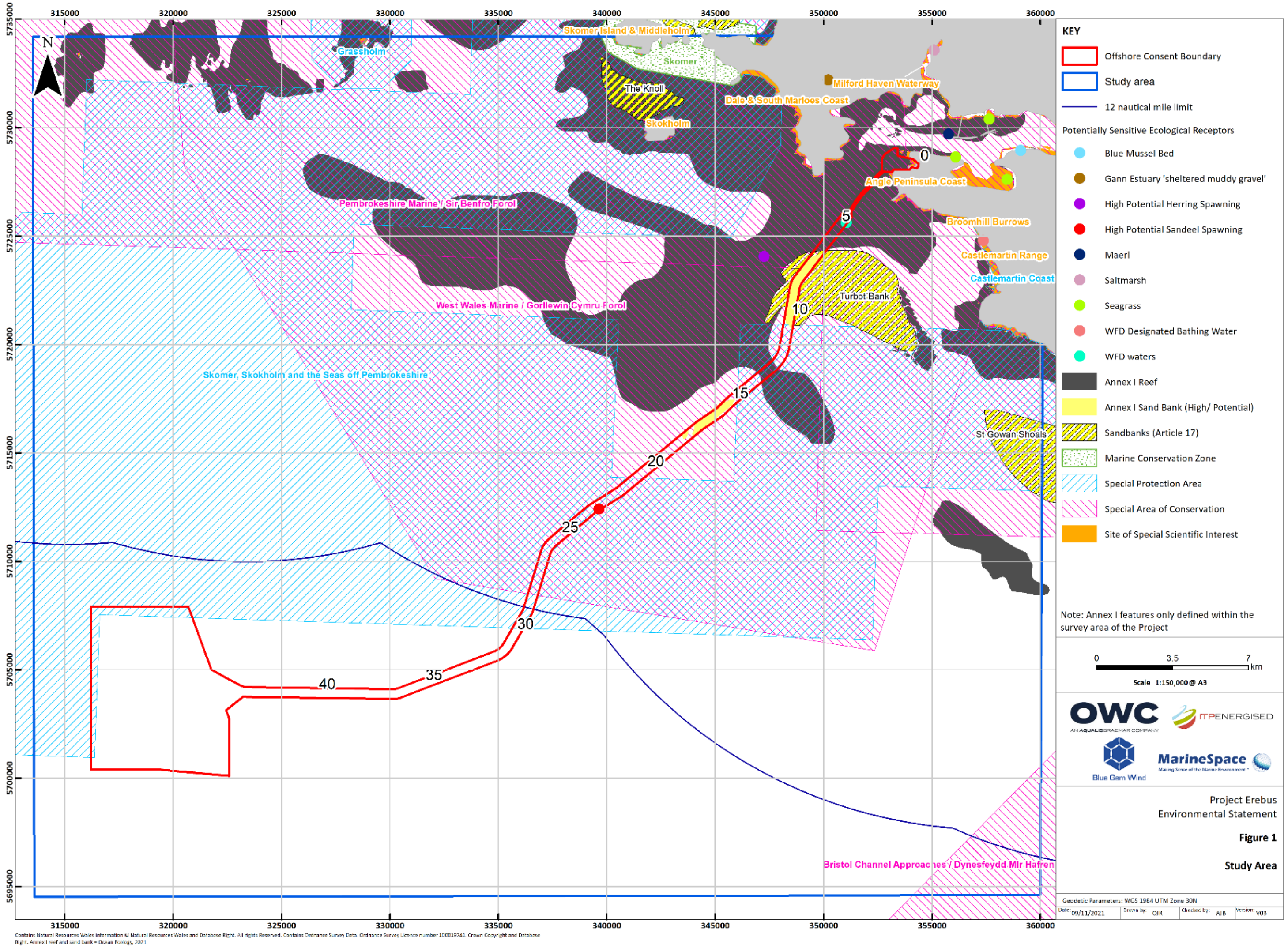


Figure 2-1: Project Erebus offshore wind farm marine and coastal processes study area

2.2 Potential Impact of Fine Sediment Plumes on Maerl Beds in Milford Haven

2.2.1 Introduction

2.2.1.1 In its statutory consultee response to the Project ES, NRW Advisory raised the following specific query relating to the assessed potential impact of fine sediment plumes during export cable burial/landfall works. The following sections provide a more detailed response to this query.

NRW Advisory Comment

We agree that the sediment plumes (sand, gravel and fines) arising from cable laying activities at the array and ECC will not affect physical processes and seabed morphodynamics and we welcome that the sediment dredged during sand wave levelling will be disposed of locally and will remain in the marine environment. However, suspended sediment transport is considered a pathway for other receptor features. Concerns have been raised by the marine and coastal benthic specialists as to the potential for the fine sediment plumes arising from the trenching activities across the intertidal of West Angle Bay and also arising from the Bentonite release during HDD, to advect toward the Maerl Beds in Milford Haven (Graphic 6.14) which are only 1.7 km from the proposed works and when the maximum spring tidal excursion in the Milford Haven is between 5-8km. The assessment of effects on the Maerl Beds determined that the fine sediment plume would disperse to background levels before reaching the Maerl Beds (ES Vol. 1 Ch. 6 section 6.6.2.11). However, this is based on expert judgement and not based on any evidence-based assessment. It is advised that further assessments should be carried out to confirm that the fine sediment plume will not advect into the area of the Maerl beds which are very sensitive to very small amounts of fine sediment deposition.

2.2.1.2 The supplementary information in this section uses additional numerical modelling (not previously undertaken for the EIA stage) to assess the magnitude, duration and extent of local increases in SSC, within or close enough to Milford Haven to further describe the potential impact on the Maerl Beds that are present, namely due to:

- Cable burial by ploughing, trenching and jetting (including initial installation and any subsequent cable repairs and/or remediation in the Operational phase); and
- Release of drilling fluid (bentonite) during Horizontal Directional Drilling (HDD) punch out.

2.2.1.3 Any material mobilised by the activities listed above may be transported away from the disturbance location by the local tidal regime. According to the source-pathway-receptor model:

- Disturbance and release of sediment is considered as the source of potential changes to SSC in the water column;
- Tidal currents act as the pathway for transporting the suspended sediment; and
- The receptor is a feature potentially sensitive to any increase in suspended sediments and consequential deposition.

2.2.1.4 Sediment disturbed and released into the water column will settle downwards at a rate dependent upon its grain size. During the settling phase, the sediment plume will be advected away from the point of release by any currents that are present, and will be dispersed laterally and vertically by turbulent diffusion. The horizontal advection distance will be related to the flow speed and the physical properties of the sediment. The maximum near-bed level of SSC is expected to be found where the main body of the settling plume of sediment reaches the seabed.

2.2.1.5 Coarser grained sediments (i.e. sand/gravel) will behave differently to finer grained sediments (i.e. silt/clay/mud), when released into the water column. The disturbance of coarse grained or consolidated material is likely to give rise to high SSCs in the vicinity of the release location, but is also likely to settle out of suspension quickly (e.g. in the order of seconds to minutes), so any sediment plumes are likely to be localised and of short duration. In contrast, fine grained material will tend to remain in suspension for a longer period of time (in the order of hours to days), potentially resulting in an increase in SSC over a larger area, but at a progressively reduced concentration, due to ongoing advection and dispersion over time from the original release location.

2.2.1.6 Similar variability is expected when considering any resulting changes in bed level due to resettlement of the material in suspension. Coarser material will tend to give rise to thicker, but more localised, changes in bed levels, whereas fine grained material may give rise to smaller changes in bed levels over a wider area. The exact pattern of re-deposition of sediment to the seabed will depend on the actual combination of operational methods and environmental conditions at the time of the event, which will be variable. The total volume of sediment disturbed is, however, known with greater certainty, and a range of potential combinations of deposit shape, thickness and area (corresponding to the same total volume) can be more reliably provided, as a subset of all possible combinations.

2.2.2 Relevant Baseline Conditions

2.2.2.1 A description of the baseline environment across the marine processes Study Area is provided in ES Volume 1 Chapter 6: Marine and Coastal Processes. The baseline draws upon the findings of Project-specific oceanographic, geophysical and geotechnical surveys (undertaken 2020/21), and other pre-existing data.

2.2.2.2 A summary of the relevant baseline characteristics within and nearby to the offshore array area of the Proposed Development is provided below, based on the data sources described in ES Volume 1 Chapter 6: Marine and Coastal Processes:

- Tidal current speeds vary continuously in response to flood/ebb, spring/neap, equinox/solstice and other tidal cycles, as well as with depth and in conjunction with any non-tidal surge influence. Based on the site specific metocean survey in the array area, and other hindcast data, peak depth averaged current speed on a mean spring tide within the offshore array area is approximately 0.6 to 0.8 m/s, increasing gradually along the ECC to between approximately 1.0 and 1.4 m/s in the approaches to Milford Haven. In the mouth of Milford Haven, but outside (west) of West Angle Bay, speeds are lower, approximately 0.6 m/s. Within West Angle Bay, currents are very low (order of a few centimetres per second), due to the limited volume of water exchanged during each tide. Peak depth averaged current speed on a mean neap tide is approximately half the spring value;

- A total of 26 water samples were collected in the inshore/nearshore ECC (between the landfall and KP 8), during a Project-specific survey undertaken in November 2020. The observed SSC from these samples was nearly always less than 10 mg/l, which is low in absolute and relative terms; only one sample, from close to the seabed near the entrance to West Angle Bay, was higher, at 23 mg/l. Monthly averaged satellite imagery of suspended particulate matter (SPM) also suggests that average (surface) SPM concentration is generally low throughout the ECC and array area during summer months (around 3 mg/l at the landward end of the ECC). SPM concentrations increase slightly during winter, but are still relatively low in absolute terms, increasing to approximately 8 mg/l in the approaches to West Angle Bay. In practice, higher values (potentially several tens or hundreds of mg/l) are realistically anticipated in some locations during larger spring tides and during storm conditions, with the greatest concentrations generally encountered closer to the seabed, especially where and when wave action penetrates to the seabed;
- SSC varies with height in the water column. Sediment is naturally re-suspended by the action of currents and waves at the seabed, so SSC levels are greater in the lower part of the water column. Sediment grains naturally settle downwards under gravity but are also re-suspended upwards by turbulence, which is greater nearer the seabed. This results in an equilibrium state, and a non-linear profile of SSC (i.e. rapidly decreasing SSC with height above the seabed);
- Based on the results of the 2020 geophysical survey of the ECC, the particle size analysis of numerous seabed grab samples, and the interpretation of those data in the Project Ground Model (Blue Gem Wind, 2021), seabed sediments are characterised as:
    - **In the approaches to Milford Haven and West Angle Bay (KP 5 to 3)**: rock platform (excluding Rows Rocks channel). Locally thin or absent veneer (<1 m) of sandy gravel or gravelly sand; and
    - **Within Rows Rocks channel and West Angle Bay (KP 3 to 0)**: Rows Rocks channel is incised into the bedrock platform and locally infilled with between 5 to10 m of muddy sandy gravel and sands (Blue Gem Wind, 2021). Areas of sandy gravel and sandy mud, and exposed bedrock, occur in the approaches to West Angle Bay. West Angle Bay itself is a sandy beach (with some muds) of variable thickness, overlying a rocky platform.

2.2.2.3 A summary of the sediment types within the array area, ECC and at the cable landfall (West Angle Bay) is presented in Figure 2-2.

2.2.2.4 The location of the dead and live Maerl beds used in this updated assessment was sourced from the Lle Geo-Portal (http://lle.gov.wales, accessed on 12/7/2022).

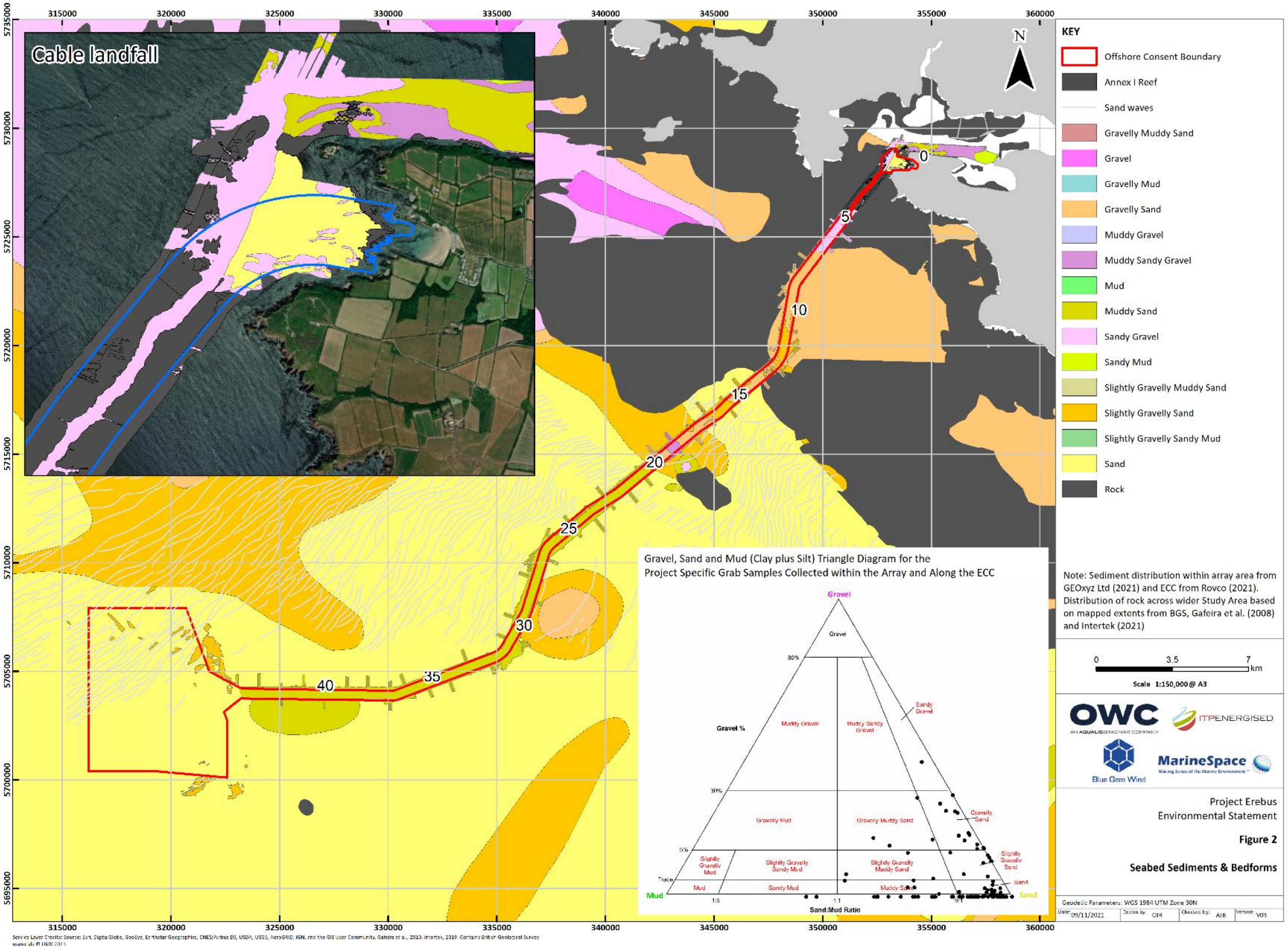


Figure 2-2: Seabed sediments in the array area and ECC, and at the cable landfall (West Angle Bay)

2.3 Sediment Plume Model Design

2.3.1.1 A bespoke hydrodynamic (tide only) and sediment plume model has been developed and used for this assessment, based upon the calibrated ABPmer SEASTATES Tide and Surge Hindcast model (ABPmer 2017). The model has been refined and reassessed for the purpose of simulating detailed hydrodynamic processes for the Project Floating Offshore Windfarm and associated export cable route. The hindcast modelling for this study has been undertaken using the MIKE21FM (flexible mesh) software package from the Danish Hydraulic Institute (DHI).

2.3.1.2 The hydrodynamic model was developed to inform metocean design criteria, that are being used to consider and inform the detailed engineering design of the Project. This particular model was finalised after the conclusion of the EIA process, and has only become available more recently to inform the additional plume modelling described in this supplementary note.

2.3.2 Model grid

2.3.2.1 The hydrodynamic model is a 2-D, depth averaged, flow model. The hydrodynamic(HD) model grid is a flexible mesh design (interlocking triangular elements of varying shape and size), covering the North West European Continental Shelf and North Sea, between approximately 43 °N to 65 °N, and 20 °W to 13 °E, as shown in Figure 2-3. The domain extent and resolution of the wider model area matches that of the separately validated ABPmer SEASTATES European Shelf Tide and Surge Hindcast model, which well simulates tidal (and residual) components of water level and flow across the model domain (ABPmer, 2017). The model grid has been refined further for this study (as illustrated in Figure 2-4 and Figure 2-5 to the following:

- Approximately 1 km spatial resolution across the array area, and finer along selected areas of the ECC;
    - Approximately 80 m along the nearshore ECC, in and around Rows Rock Channel, and into West Angle Bay; and
    - Approximately 150 m elsewhere within Milford Haven Estuary.

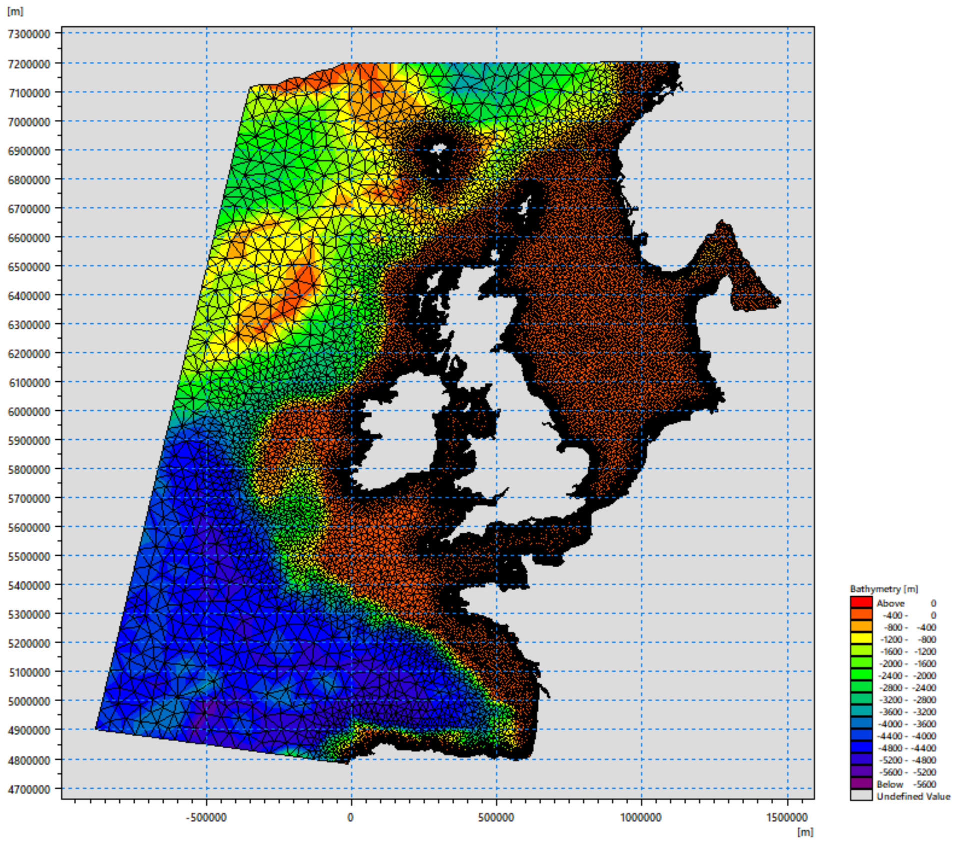


Figure 2-3: ABPmer Hydrodynamic model domain

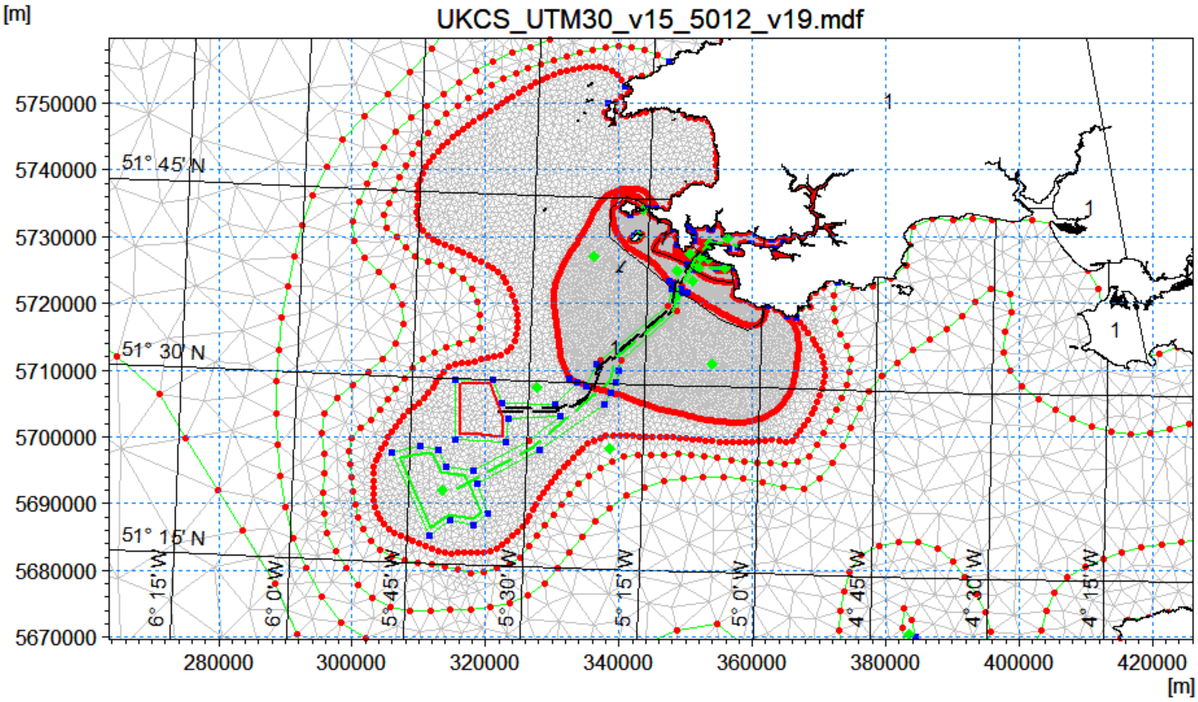


Figure 2-4: Areas of increased mesh resolution – offshore and array areas

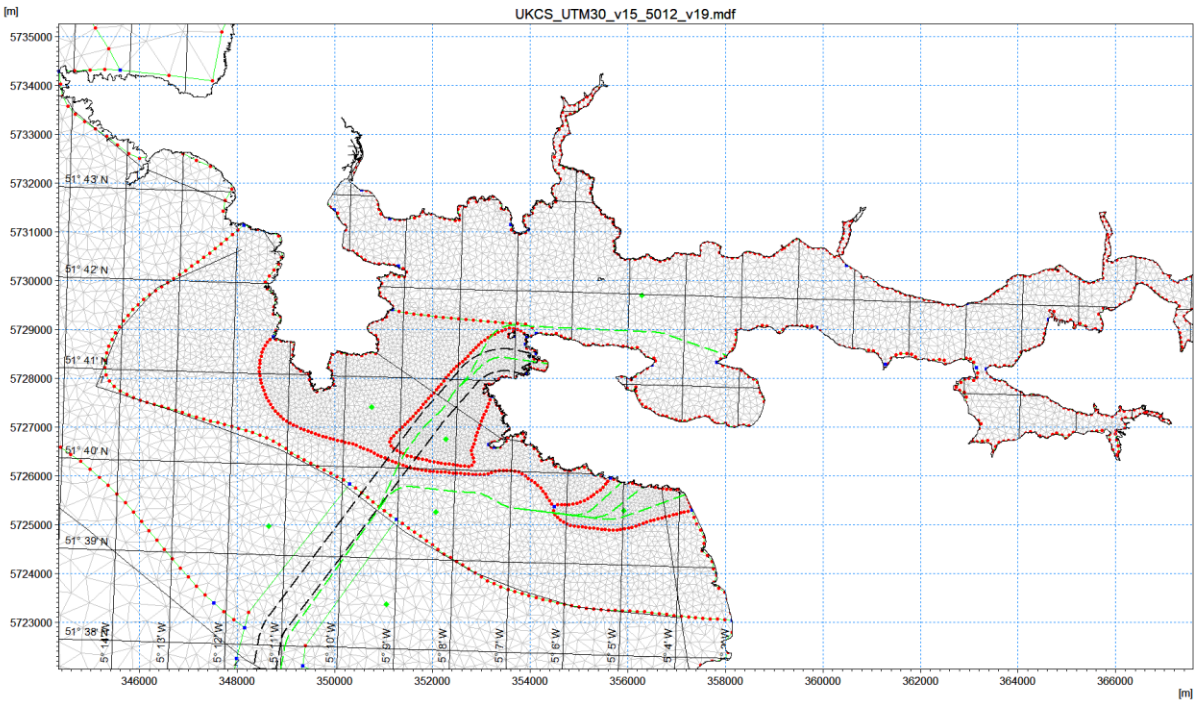


Figure 2-5: Areas of increased mesh resolution – nearshore and within Milford Haven

2.3.3 Bathymetry

2.3.3.1 The model bathymetry has been compiled from the data sources listed in Table 2-1. Data are presented in order of priority in the model, i.e. where two datasets spatially overlap, the data closer towards the top of the tabulated list is used in priority to the lower listed data.

2.3.3.2 Data priority has been assessed based on the data coverage, resolution and the date that measurements were taken. Where high resolution spatial data are available, these data have been subsampled to a resolution appropriate for the underlying mesh before interpolation. This manages the overall data size during model build. All datasets have been converted to mean sea level (MSL) for inclusion in the model: Chart Datum (CD) to MSL adjustments are taken from the Admiralty Tide Table, while Ordnance Datum Newlyn (ODN) to MSL conversions are based on the VORF correction surface[1].

Table 2-1: Bathymetry data summary

Bathymetry ID	Data Source
Erebus site - survey data (2020 and 2021)	Client supplied, Project specific, bathymetric data.
UKHO	United Kingdom Hydrographic Office (UKHO) survey data, available via the 'INSPIRE' portal (https://data.gov.uk/inspire)

1 https://www.ucl.ac.uk/civil-environmental-geomatic-engineering/research/groups-centres-and-sections/vertical-offshore-reference-frames-vorf

SEACAMS (2017)	SEACAMS Project, part-funded by the European Regional Development Fund through the Welsh Government, within the School of Ocean Sciences, at Bangor University.
EMODNET	European Marine Observation and Data Network (EMODnet) - http://www.emodnet.eu/bathymetry
CMAP	Digitised bathymetric contours supplied by DHI's CMAP
Lle composite LiDAR	http://lle.gov.wales/GridProducts#data=LidarCompositeDataset
SEASTATES (Hydrodynamic hindcast)	European Marine Observation and Data Network (EMODnet) - http://www.emodnet.eu/bathymetry United Kingdom Hydrographic Office (UKHO) survey data, available via the 'INSPIRE' portal (https://data.gov.uk/inspire)

2.3.4 Hydrodynamic Model Boundaries

2.3.4.1 The (tide only) HD model is forced using four open tidal water level boundaries. Three are located offshore of the continental shelf edge, and one at the entrance to the Baltic Sea. Water levels vary in both space and time along the open boundaries. The boundary water levels are predicted using the DTU10 global database of 10 major tidal harmonic constituents[2].

2.3.5 Sediment Plume Modelling Approach

2.3.5.1 The sediment plume modelling is undertaken using a particle tracking approach. Particle tracking is a sub-module of the hydrodynamic model described above, also using the MIKE by DHI software.

2.3.5.2 The sediment release is simulated as numerous discrete particles, each representing a relatively small mass of sediment in suspension. Particles are released into the simulation at a rate of 1 particle/second, with the mass of each particle representing 1 second of sediment mass at the representative release/disturbance rate.

2.3.5.3 The particles are released at a fixed elevation above the seabed (5 m) to conservatively represent the initial energetic vertical dispersion of the sediment. Fine sediment is assigned a conservatively low settling rate of 0.0001 m/s. As such, the sediment will remain in suspension (and mobile in the model) for approximately 14 hours (the time needed to settle 5 m at the settling rate). In practice, fine sediment may remain in suspension for longer due to resuspension by natural turbulence, but would be subject to continuous ongoing dispersion to lower and lower (not practicably measurable) SSC.

2.3.5.4 The new plume modelling specifically considers the effect of the finer sediments that are likely to remain in suspension for long enough to contribute to elevated SSC, over timescales and distances large enough, to interact with the Maerl beds in Milford Haven Estuary. Coarser material (i.e. sands and gravels) will settle to the seabed too rapidly to affect the Maerl beds at all (within seconds to minutes and, therefore, with a spatial extent of tens to a few hundreds of metres), and so are not included in these plume models.

[2] http://www.space.dtu.dk/english/Research/Scientific_data_and_models/Global_Ocean_Tide_Model

2.3.5.5 The hydrodynamic model provides the time varying flow field information to inform the patterns and rate of advection and dispersion of the particles over time. The hydrodynamic model was run for a continuous 15 day simulation period from 20 March to 8 April 2021, providing a range of realistic conditions, including depth averaged flow speed, direction and surface elevation data, at ten-minute intervals. For the plume modelling, representative mean spring and mean neap tidal range conditions were identified around 29 March and 6 April 2021, respectively.

2.3.5.6 The particle tracking model records the horizontal and vertical position of the individual particles over time. Spatial patterns of SSC are calculated by the model at each timestep, based on the total mass of sediment (particles) within each model mesh element, divided by the volume of water in that element. Spatial patterns of sediment deposition are similarly calculated, based on the total mass of particles that has fully re-settled in each model mesh element, divided by the area of seabed in that element.

2.3.5.7 The plume scenarios are designed according to the realistic worst case design scenarios (described in the following sections) for:

- Export cable burial close to the Landfall; and
- Drilling fluid (bentonite) release during HDD at the Landfall.

2.4 Cable Burial Close to the Landfall

2.4.1 Sediment Release Scenario

2.4.1.1 The ECC route extends from the central eastern edge of the offshore array area to a landfall in West Angle Bay, within Milford Haven Estuary. Offshore export cables will be installed by burial into the seabed wherever possible, with external cable protection used in areas where burial is not possible.

2.4.1.2 Trenching associated with the burial of the cables may cause a sediment plume in the nearshore area, which may then advect towards the location of the Maerl beds in Milford Haven Estuary.

2.4.1.3 The impact of cable burial activities mainly relates to a localised and temporary resuspension of sediments by the trenching tool, and subsequent settling of that material (BERR, 2008). The exact nature of the disturbance effect is mainly determined by the local soil type and conditions, the burial depth, and the method/tool used for the local section of cable.

2.4.1.4 For the Proposed Development, the realistic worst-case scenario for sediment release caused by cable burial is characterised in Table 2-2. Sediment disturbance during cable burial is limited to the location and time of active cable burial. As such, the realistic worst case scenario information mainly considers local trench dimensions and local rates of sediment disturbance. The total volume of sediment disturbance for the whole cable route is not relevant to the assessment, and so is not presented here.

Table 2-2: Realistic worst case scenario for sediment release by cable installation

Parameter	Realistic Worst Case Scenario	Working and Other Assumptions
Number of export cable trenches	1	1 single or 2 bundled cables.
Length of export cable trench	49 km	-

Parameter	Realistic Worst Case Scenario	Working and Other Assumptions
Maximum rate of cable burial	500 m/hr	Fastest rate through softer sediments.
Total length of all array cables	23.9 km	The maximum total length of inter-array cables will be installed as multiple shorter lengths (number, length and routes to be determined as part of the cable burial design plan).
Methods of array and export cable burial	Jetting Mass flow excavator	Jetting and MFE methods have the greatest potential to energetically fluidise and eject material from the trench into suspension. By contrast, the other cable installation techniques described in the Project design statement (e.g. ploughing) are expected to re-suspend a smaller amount of material into the water column. Due to spatial variation in the geotechnical properties of the underlying geology within this region, it is possible that a combination of techniques may be used.
Maximum dimensions of array and export cable trench	Up to 1 m wide, and 3 m deep, with a 'U' shaped profile.	Jetting or MFE might be used at any location but, in practice, would only be used where surficial sediments are suitable. Target burial depth will typically be up to *circa* 3 m. Conservatively assumes 100% of material is ejected from the trench. In practice, the tool and methods used will normally retain the majority of sediment within the trench, by design, to backfill and provide protective cover.
Volume of sediment disturbed per metre progress	3.0 m^3	1 m wide x 3 m deep
Sediment mineral density	2,650 kg/m^3	Assumed value for quartz sand (Soulsby, 1997).
Consolidated packing density	0.6	Assumed value for a typical, medium sorted sand (Soulsby, 1997).
Total sediment disturbance rate	662.5 kg/s	(3.0 m^3 x 2,650 kg/m^3 x 0.6) x (500 m/hr divided by 3,600 s/hr)
Representative proportion of fine (mud and clay) material.	5%	Representative value based on sediment grab samples from the area.
Fine sediment disturbance rate	33.125 kg/s	662.5 kg/s x 5%

2.4.1.5 The location of the sediment release for cable burial moves along the cable route, over time, starting in West Angle Bay and moving offshore at a rate of 500 m per hour. The moving release continues for 12 hours, ending at around KP 6, which is sufficiently far offshore of Milford Haven Estuary that the locally generated plume is only being dispersed into the offshore environment.

2.4.1.6 Due to the relatively long duration of the release within the mouth and approaches to Milford Haven, four key timing scenarios are tested (timing in hours relative to high water, HW):

- Start of release and movement along the cable route at HW-6 (approximately low water slack);
- Start of release and movement along the cable route at HW-3 (approximately peak flood);
- Start of release and movement along the cable route at HW (approximately high water slack);
- Start of release and movement along the cable route at HW+3 (approximately peak ebb); and
- In all cases, the release occurs within the area clearly exchanging water with Milford Haven Estuary for at least the first 6 hours following the start of release and movement along the cable route.

2.4.1.7 The jetting burial process fluidises a limited volume of sediment within the seabed, through which the cable is inserted. By design, the process is intended to bury the cable and so only a minimal proportion of the fluidised sediment is expected be actually ejected from the trench. The exact proportion ejected may vary depending on the soil type and tool/method used, but values of 20 to 30% have been used in previous investigations of this type (ASA, 2005). Mass flow excavation tools may also fluidise the bed to a degree but may also be used to excavate an open trench, in which case, a greater proportion of the material may be displaced. For the purposes of this investigation, it is conservatively assumed that 100% of material is ejected from the maximum trench profile dimensions, to an elevation of 5 m above the local seabed level.

2.4.1.8 The seabed and sub-seabed sediment composition within the ECC in the approaches to Milford Haven and West Angle Bay is relatively similar. The majority of disturbed material will be mostly (90% or more) sand and gravels, with typically around 5%, but up to 10%, fines also present.

2.4.1.9 A realistic scenario of 5% fines is modelled (representing any combination of mud and clay size material, with a sufficiently low settling velocity to remain in suspension for extended periods of time). In practice, releases comprising a larger proportion of fines are only likely to occur for relatively short time periods in relatively localised parts of the route, which would not affect the overall description of plume effects at relatively distant locations.

2.4.1.10 The results of the plume modelling are proportional to the assumption of 5% fines present. For example, results for an alternative 10% fines scenario can be estimated by doubling the modelled SSC magnitude. As the location and time of release, and the rate of advection and dispersion are the same, the duration and spatial extent of the effects for 10% fines are the same as modelled for 5% fines.

2.4.1.11 The majority (90% or more) of the disturbed sediment will comprise sands and gravels. In close proximity to the active trenching, the total disturbed sediment (sands, gravels and fines) is very concentrated, with minimal time for dispersion, and will likely result in very high levels of SSC. Due to the relatively low height of ejection and rapid rate of resettlement for the majority sand and gravel fractions, the extent and duration of such very high SSC levels are, realistically, very limited. As stated above, sands and gravels have not been included in these new plume models, as they will typically settle out within seconds to minutes and, therefore, with a spatial extent of tens to a few hundreds of metres. The magnitude, duration and extent of the potential impact of sand and gravel plumes has been described and quantified for various scenarios using spreadsheet models in the ES Volume 1 Chapter 6: Marine and Coastal Processes, and supporting technical Annexes.

2.4.1.12 Therefore, this new plume modelling specifically considers the effect of the finer sediments that may remain in suspension and contribute to elevated SSC over timescales and distances larger than that already assessed. The contribution of disturbed sands and gravels to local SSC around the cable route (not extending at all, under any scenario, to the location of the Maerl beds) is not included in these results. The results are shown in Figure 2-6 to Figure 2-9 for spring tides; in Figure 2-10 to Figure 2-13 for neap tides; and summarised in section 2.4.4.

2.4.2 *Cable Burial During Spring Tide Conditions*

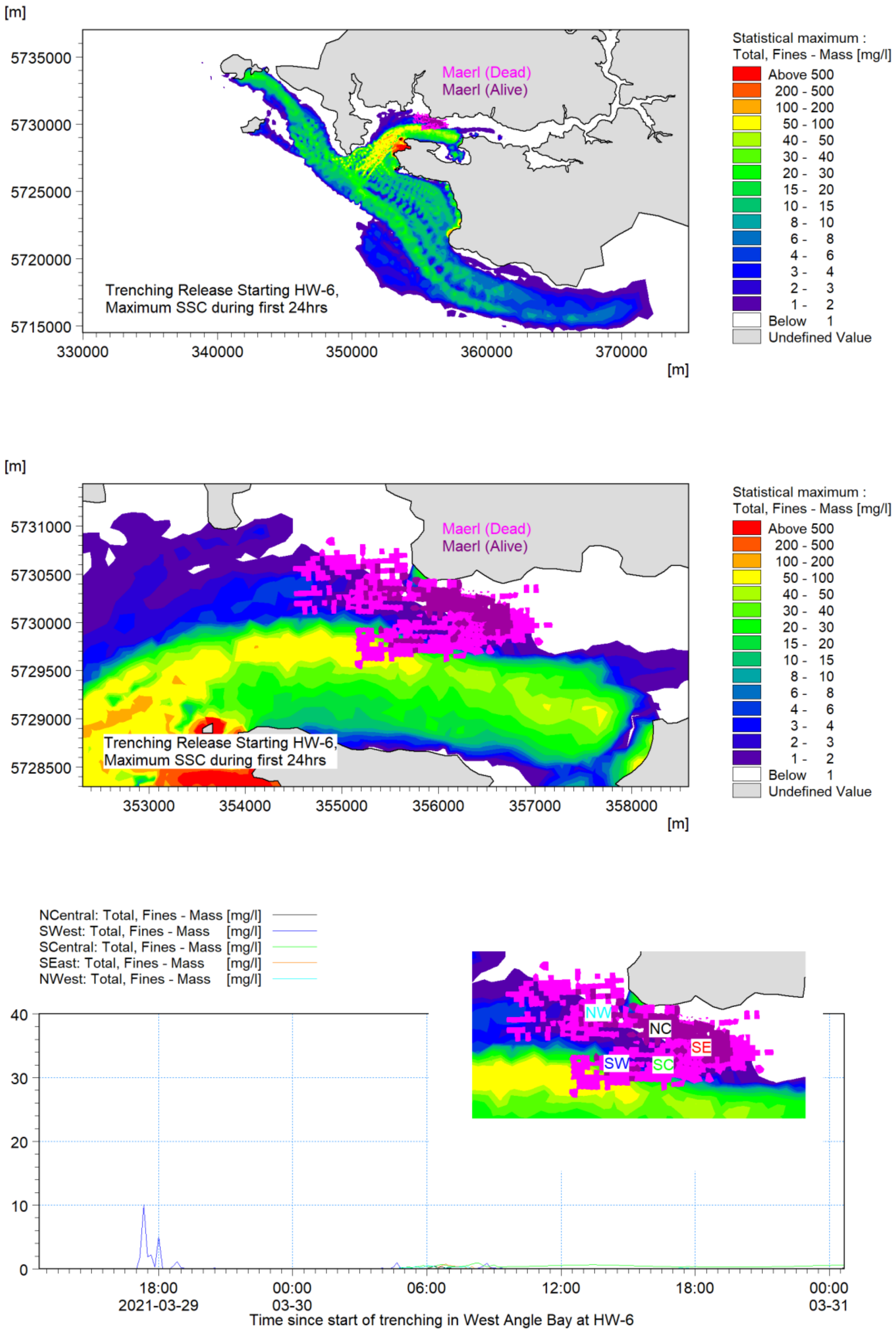


Figure 2-6: Maximum local SSC at any time during cable burial activities on spring tides, starting at HW 6 (approximately low water slack).

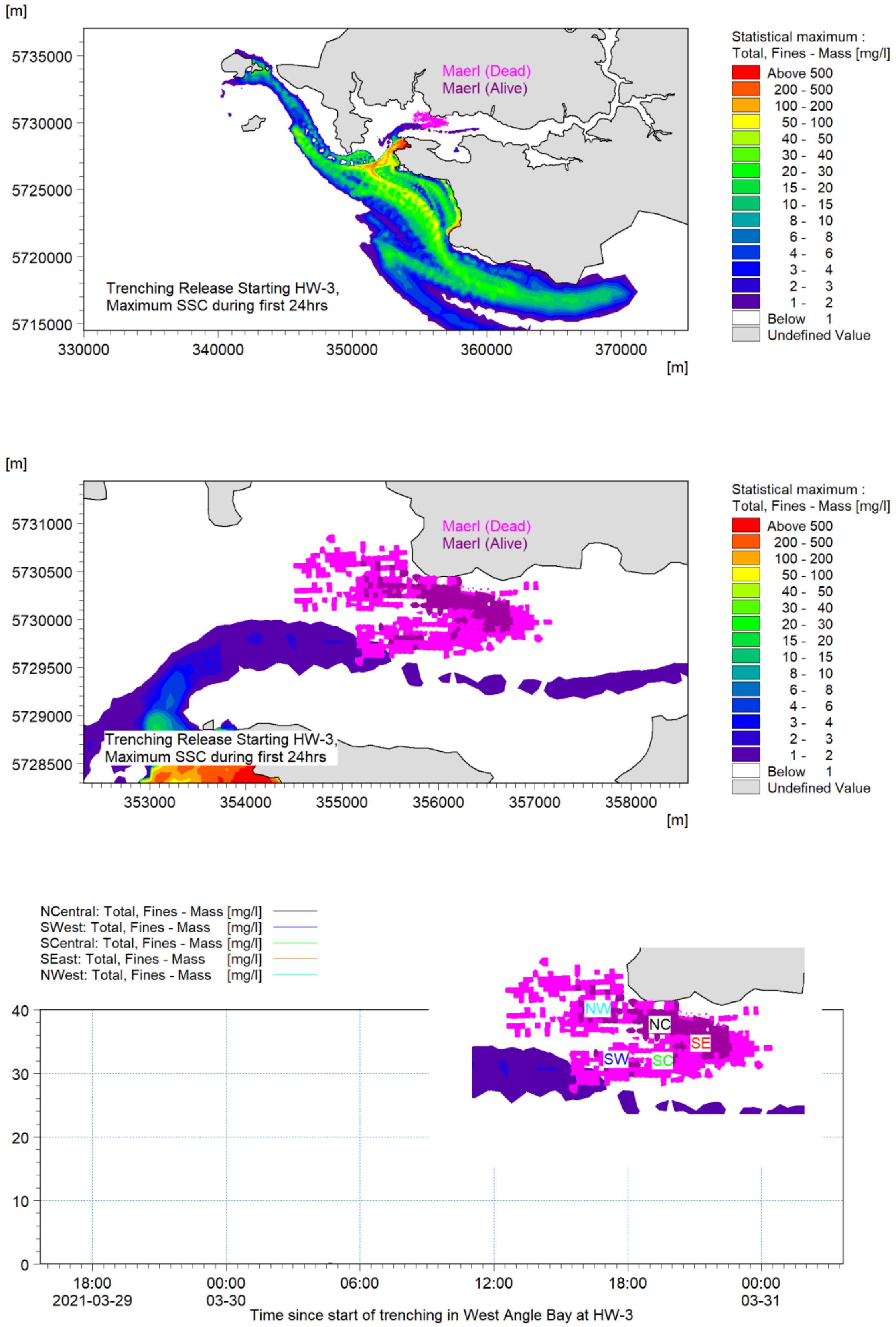
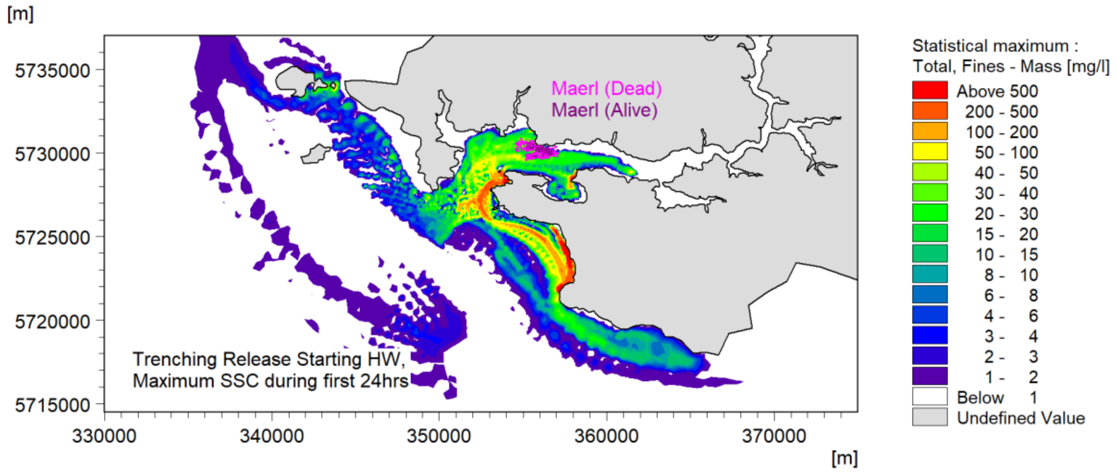
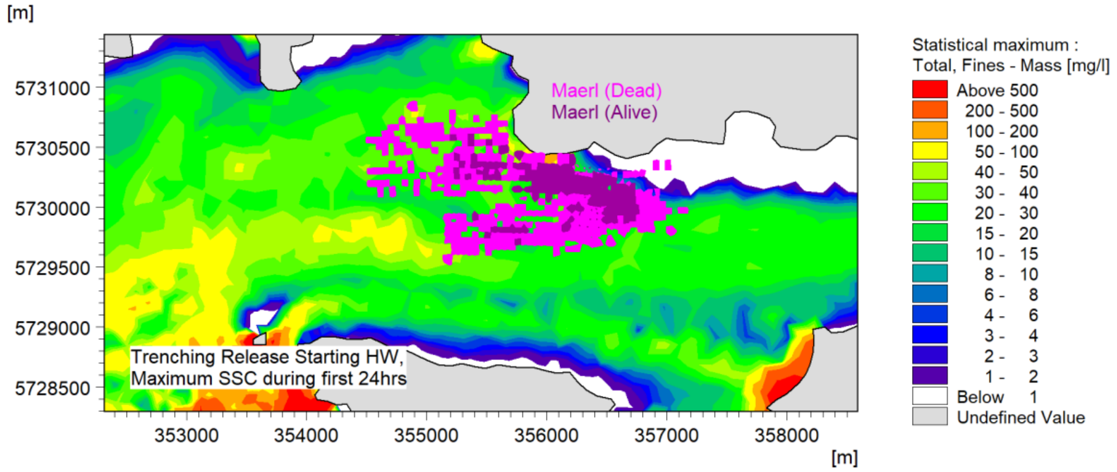


Figure 2-7: Maximum local SSC at any time during cable burial activities on spring tides, starting at HW-3 (approximately peak flood tide).





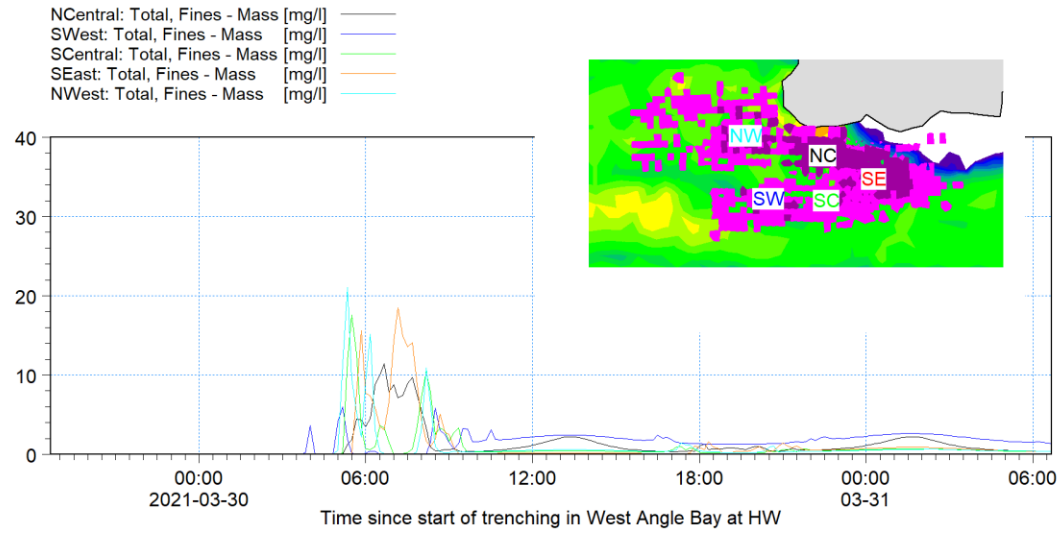


Figure 2-8: Maximum local SSC at any time during cable burial activities on spring tides, starting at HW (approximately high water slack).

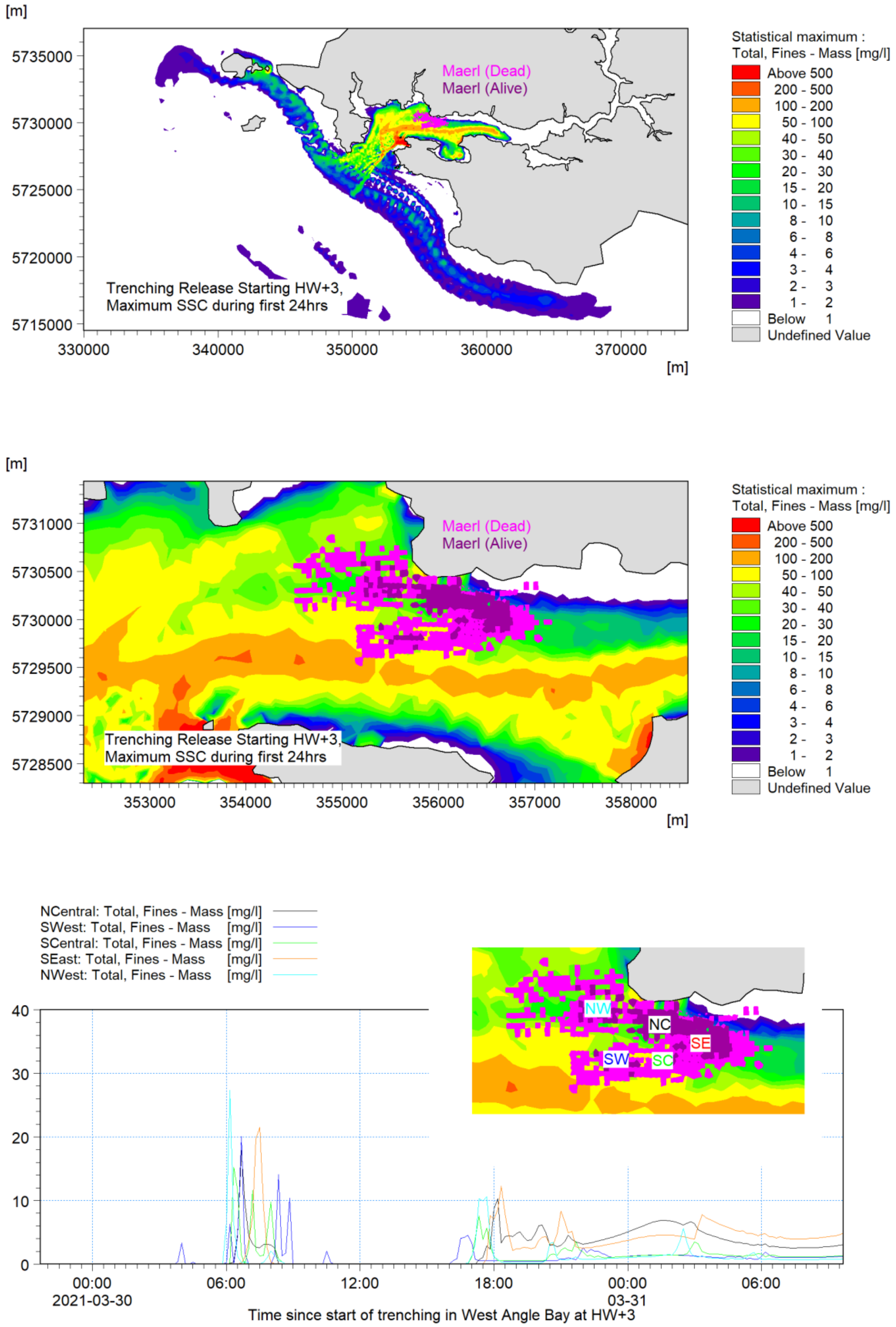
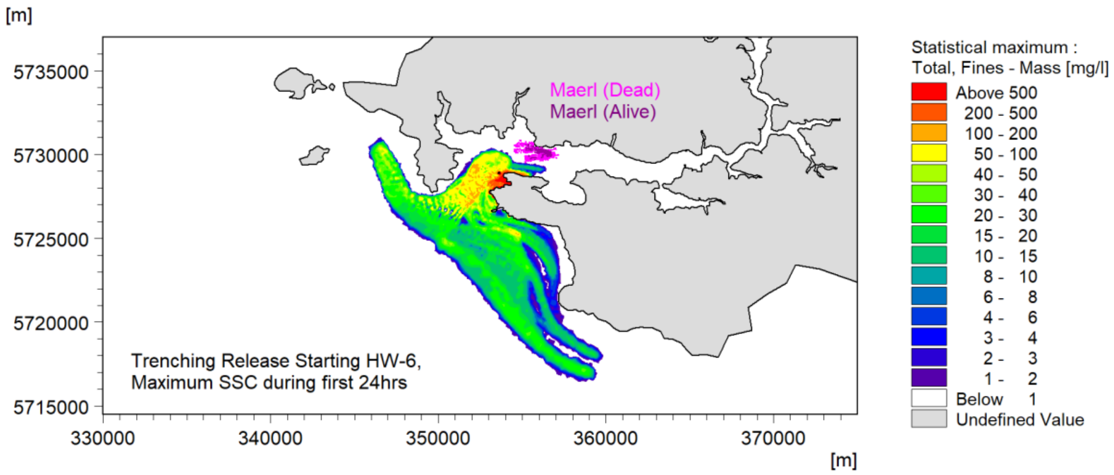
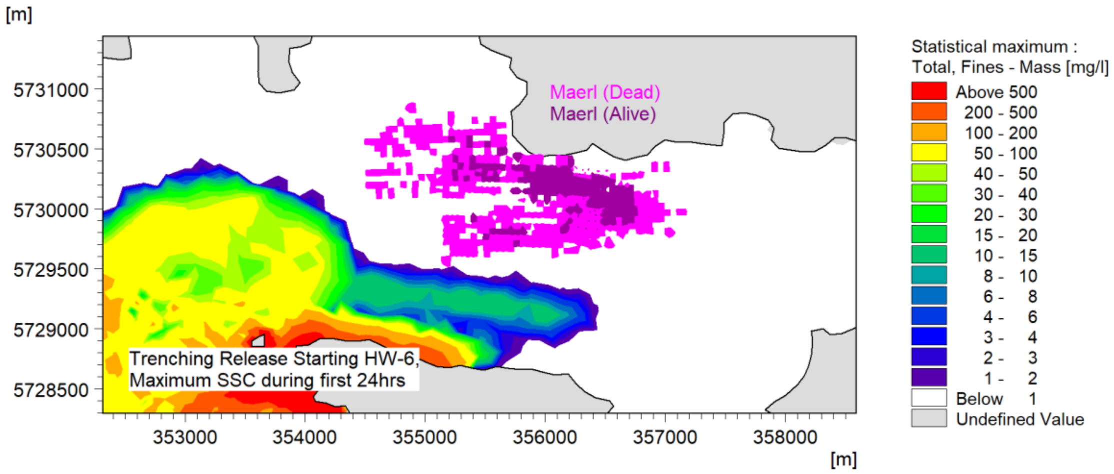


Figure 2-9: Maximum local SSC at any time during cable burial activities on spring tides, starting at HW+3 (approximately peak ebb tide).

2.4.3 Cable Burial During Neap Tide Conditions





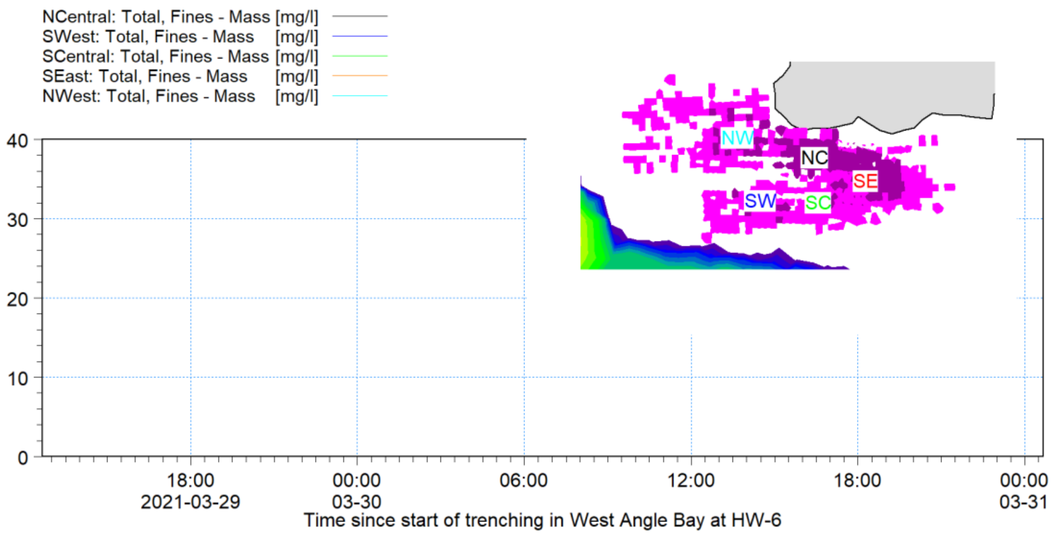


Figure 2-10: Maximum local SSC at any time during cable burial activities on neap tides, starting at HW-6 (approximately low water slack).

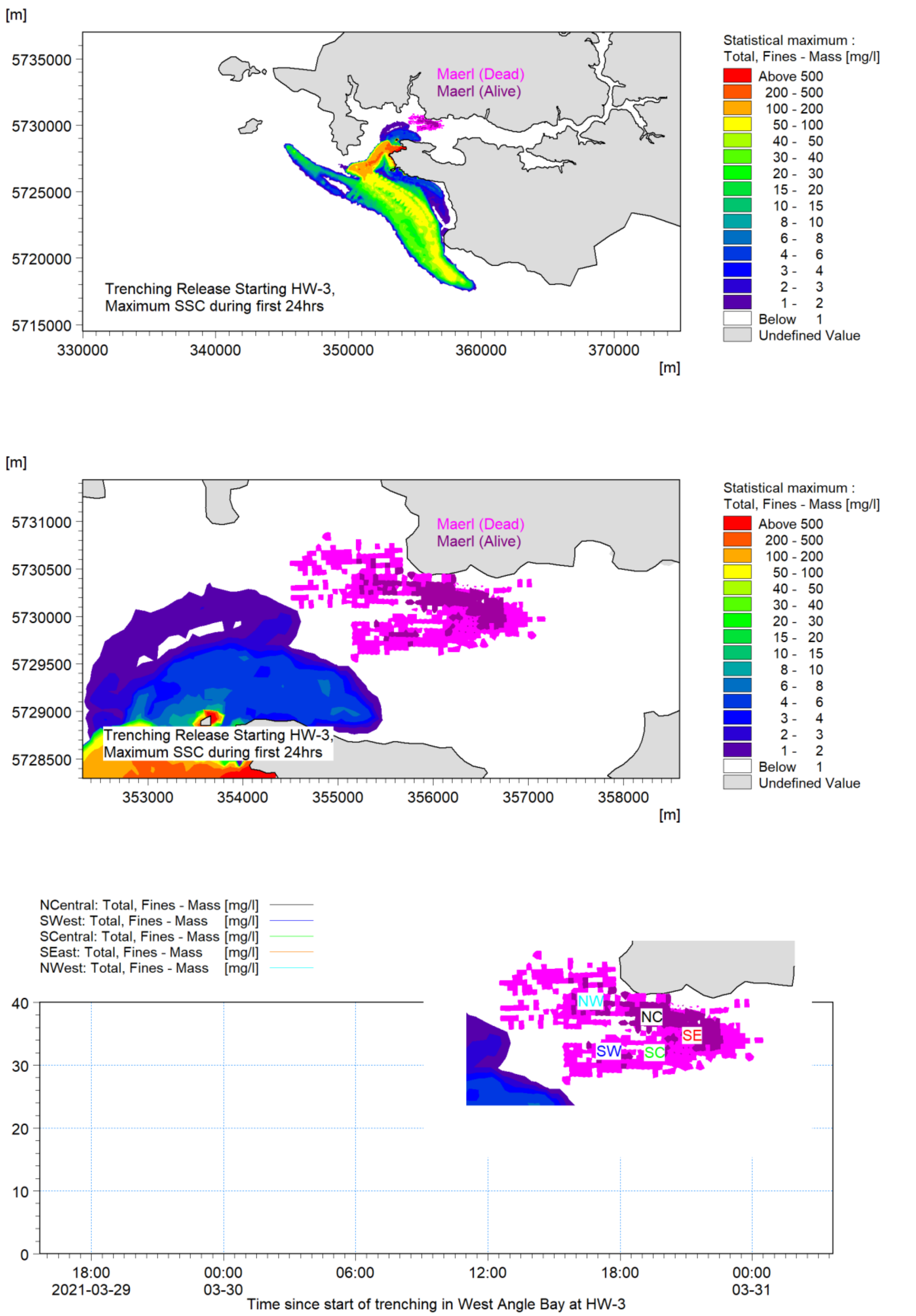
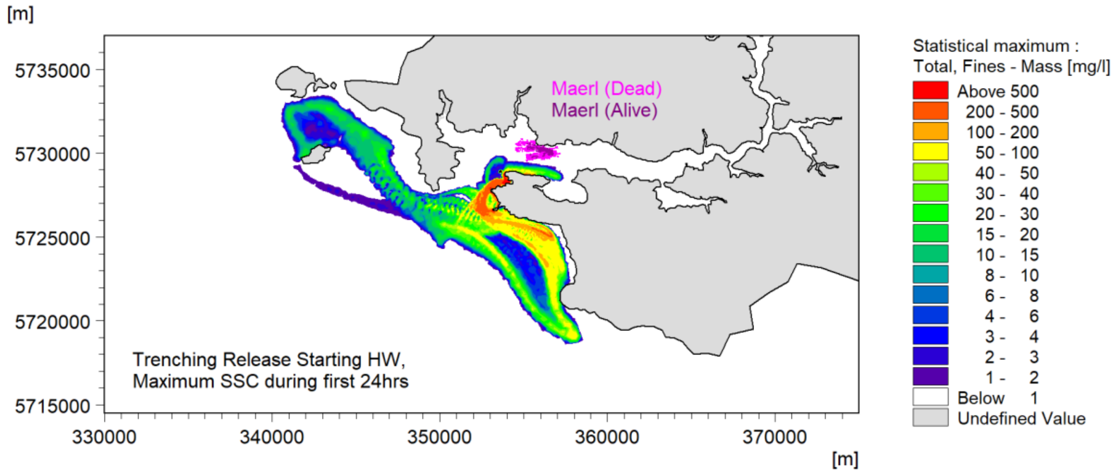
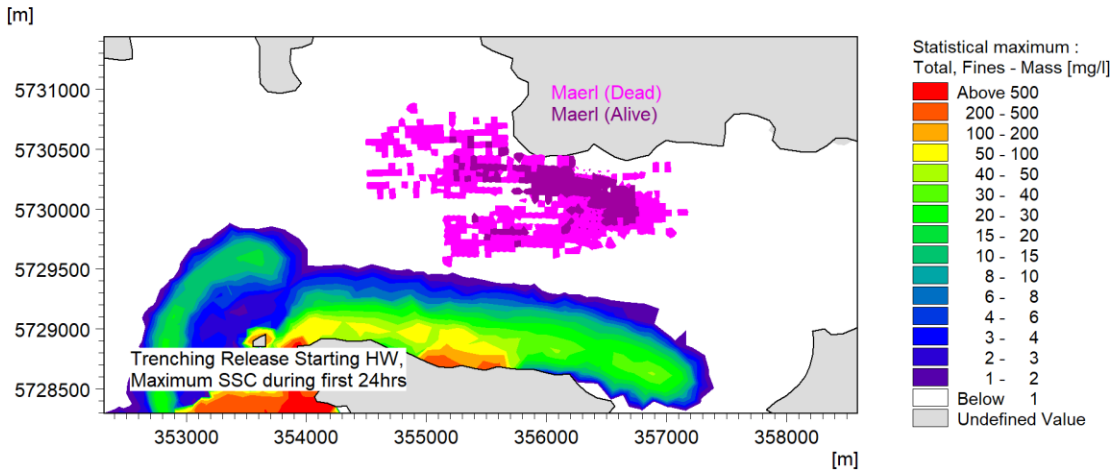


Figure 2-11: Maximum local SSC at any time during cable burial activities on neap tides, starting at HW-3 (approximately peak flood tide).





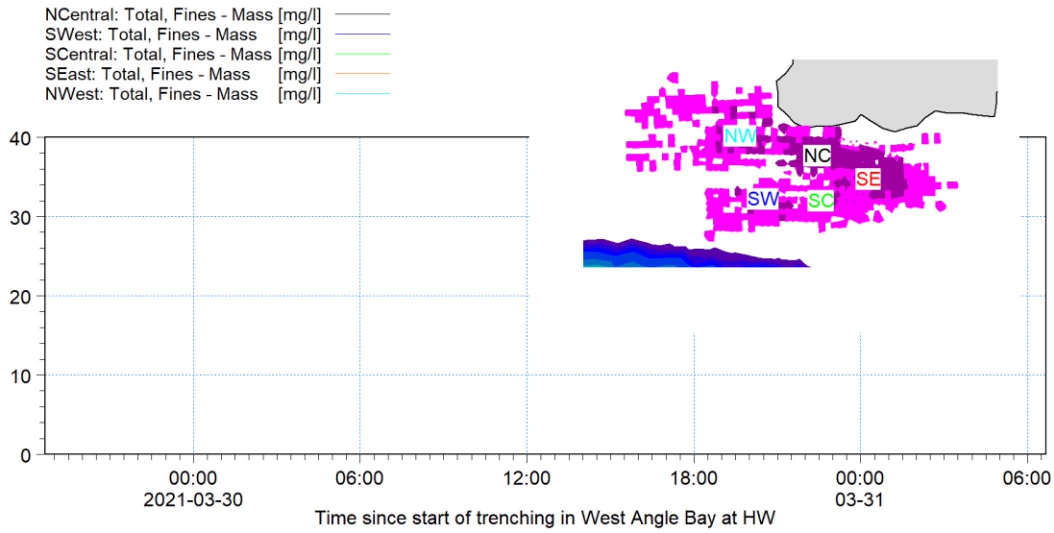


Figure 2-12: Maximum local SSC at any time during cable burial activities on neap tides, starting at HW (approximately high water slack).

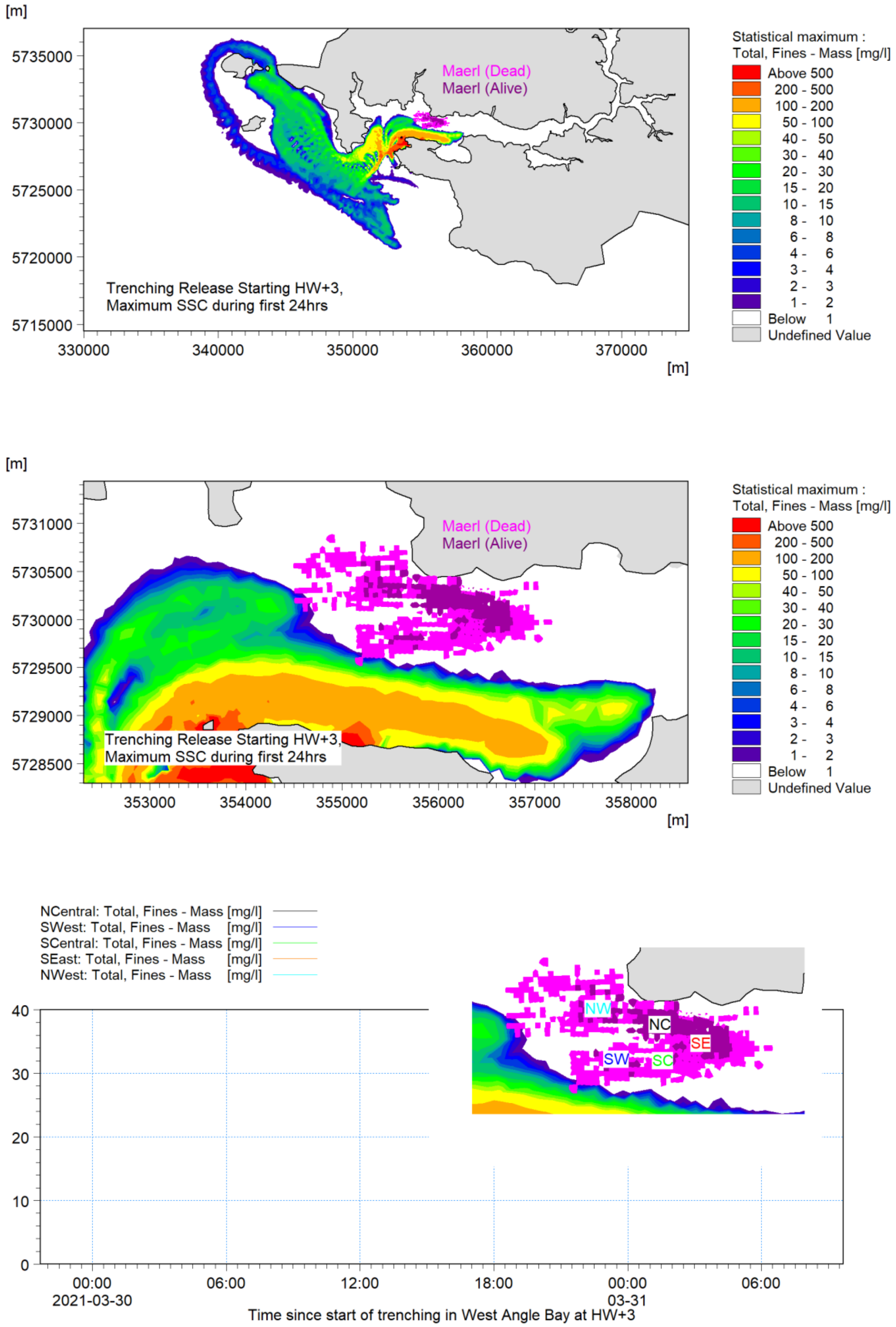


Figure 2-13: Maximum local SSC at any time during cable burial activities on neap tides, starting at HW+3 (approximately peak ebb tide).

2.4.4 Summary

2.4.4.1 The main findings of the new fine sediment plume modelling for cable burial in the approaches to Milford Haven and West Angle Bay can be summarised as follows:

- Under spring tidal conditions, fine sediment suspended by trenching in West Angle Bay and the approaches to Milford Haven can cause a weak sediment plume to extend into the estuary and overlap with the known location of Maerl beds;
    - The maximum modelled increase in SSC within the area of live Maerl beds is approximately 30 mg/l, however this peak effect was only briefly observed (order of 10 minutes) in one of the 4 release timing scenarios (starting in West Angle Bay at HW+3, approximately peak ebb tide);
    - Modelled increases in SSC within the area of live Maerl beds are more typically limited to 10 to 20 mg/l, lasting for approximately 1 to 4 hours, for 2 of the 4 release timing scenarios (starting in West Angle Bay at HW, approximately high water slack, and at HW+3, approximately peak ebb tide). This occurs because plumes arising in and close to West Angle Bay, during the initial part of these model periods, are somewhat contained and restrained by the naturally low local current speeds. By the time the sediment plume reaches the main channel flow (several hours later), the remainder of the ebb tide encourages dispersion across the estuary width. The following flood tide then transports the plume into the estuary far enough to overlap the Maerl beds;
    - Modelled increases in SSC within the area of live Maerl beds are negligible or zero at any time for 2 of the 4 release timing scenarios (starting in West Angle Bay at HW-6, approximately low water slack, and at HW-3, approximately peak flood tide). This occurs because plumes arising in and close to West Angle Bay during the initial part of these model periods are somewhat contained and restrained by the naturally low local current speeds. By the time the sediment plume reaches the main channel flow (several hours later), the flood tide is nearly complete, so does not then transport the plume far enough into the estuary to overlap the Maerl beds. Ongoing trenching work progressively moves further south during the following HW slack and ebb period, and further releases during the next flood tide are too distant to affect the Maerl beds;
- Under neap tidal conditions, modelled increases in SSC within the area of live Maerl beds are negligible or zero at any time for all of the 4 release timing scenarios;
    - The tidal current excursion distance is sufficient to advect the sediment plume to the near vicinity of the Maerl beds, however, the different patterns of current speed and direction confine the plume to the main channel to the south;
    - Similar release timing effects to that described above for spring tidal conditions are also noted;
- Sediment deposition thickness in and around the area of the live and/or dead Maerl beds (not plotted) is predicted to be <1 mm (<1 g/m^2) in all cases, which is not measurable in practice and will be, at most, comparable to normally occurring patterns as a result of natural processes and other vessel movement related disturbances; and

- Additional information related to the potential ecological aspects of the above conclusions is presented in Section 3: Marine and Coastal Ecology.

2.5 Drilling Fluid Release During HDD at the Landfall

2.5.1 Sediment Release Scenario

2.5.1.1 Horizontal Directional Drilling (HDD) is the preferred option to transition the offshore export cable to the onshore export cable at a landfall at West Angle Bay. The proposed drill punch-out location will be around (at or below) the lowest astronomical tidal water level. The drill length may be up to approximately 1,000 m from entry to exit point, with a diameter of up to 1.2 m.

2.5.1.2 The release of drilling fluid into the coastal waters at the punch-out location may cause a sediment plume in the nearshore area, that may then advect towards the location of the Maerl beds in Milford Haven Estuary.

2.5.1.3 Drilling fluid or drilling mud is a suspension of mainly bentonite clay in water, with the following functions:

- To remove cuttings from in front of the drill bit;
- Power the mud motor;
- To transport cuttings from the drill face through the annular space towards the surface;
- Lubricate the drill string during drilling phases and any conduit liners or cables during pull back;
- Cooling the reamers (cutting tools);
- Hole stabilization; and
- Creation of a filter cake against the wall of the hole to minimize the risk of loss of drilling fluid or influx of groundwater penetration into the borehole.

2.5.1.4 The drilling fluid typically consists of a low concentration bentonite – water mixture. Depending on the formation to be drilled through, the concentration is typically between 13 litres (30 kg) and 35 litres (80 kg) of dry bentonite clay per m^3 of water (30,000 to 80,000 mg/l).

2.5.1.5 The use of bentonite has several benefits:

- It is a natural material, so no chemicals;
- It is recyclable;
- It is on the PLONOR list (pose little or no risk to the environment) (OSPAR, 2021), so its discharge is not a danger to the environment; and
- Owing to the large diameter pipe and long length, the total volume of fluid used may be relatively large, but, owing to the low concentration, the total amount of bentonite is limited.

2.5.1.6 Based on the range of expected HDD lengths and maximum diameter, the maximum volume of drilling mud (and other drill cuttings) contained in one HDD conduit is estimated to be up to 1,200 m^3. Several stages of drilling (pilot hole drilling and stages of reaming) may result in smaller release events separated in time. The installation of the duct may result in a larger release of fluid from the HDD conduit (up to the total volume); however, in practice, the fluid present at this stage may have been replaced or otherwise reduced to a concentration lower than required for drilling.

2.5.1.7 The realistic worst case considered is a release of drilling mud with a conservative representative concentration of 50,000 mg/l, up to the total volume of the conduit (1,200 m^3), in a relatively short period of time (minutes to hours), at up to two subtidal HDD punch out locations for the two export cables. The realistic worse-case scenario is developed to ensure that the EIA is assessing a conservative (but realistic) rather than a theoretical worse case scenario. This is established by reviewing all the known parameters, in this case number of conduits, HDD conduit length, diameter and bentonite concentrations and then use expert judgement to define the scenario to ensure an appropriate level of realism. The worst case scenario is summarised as Table 2-3.

Table 2-3: Realistic worst-case scenario for bentonite release during HDD at the landfall

Parameter	Realistic Worst Case Scenario	Working and Other Assumptions
Number of export cables / HDD conduits	2	Maximum number of HDD conduits exiting in the subtidal area.
Maximum dimensions of one HDD conduit	Length 1,000 m Diameter 1.2 m	
Maximum volume of drill fluid in one HDD conduit	1,131 m^3	Maximum conduit volume = 1000 m x π x $(1.2\ m/2)^2$
Representative concentration bentonite in drill fluid	50,000 mg/l	Assumed value of 50 kg per m^3 (5% concentration). Conservatively realistic[3]
Total mass bentonite in one HDD conduit	56,549 kg	1,131 m^3 x 50kg per m^3
Maximum duration of release	1 hour	Assumed value – likely conservatively short, yielding a higher rate of release.
Fine sediment release rate	15.71kg/s	56,549 kg / 3600 s

2.5.1.8 The location of the sediment release for drilling fluid release is at the proposed (static) location of the HDD punch out within West Angle Bay. Once started, the release continues for 1 hour.

2.5.1.9 Due to the relatively short duration of the release, 12 key timing scenarios are tested (timing in hours relative to high water, HW):

- Start of 1hr release at HW-6 (approximately low water slack);
- Start of 1hr release at HW-5 and HW-4;
- Start of 1hr release at HW-3 (approximately peak flood);
- Start of 1hr release at HW-2 and HW-1;

[3] https://www.fps.org.uk/content/uploads/2017/01/Bentonite-Jan-2006.pdf

- Start of 1hr release at HW (approximately high water slack);
- Start of 1hr release at HW+1 and HW+2;
- Start of 1hr release at HW+3 (approximately peak ebb);
- Start of 1hr release at HW+4 and HW+5; and
- These cases account for all possible release timing scenarios over the flood/ebb tidal cycle.

2.5.1.10 Because of the time required to drill and finalise each HDD conduit, it is assumed that the two releases that will occur during the whole construction period would not happen simultaneously, and with a sufficiently long-time gap between punch out events, that no overlapping or cumulative changes to SSC are expected (potentially up to a year between the two events). The following assessment, therefore, considers the change caused during the creation of each individual HDD borehole.

2.5.1.11 In practice, the initial plume will have a very high local SSC of bentonite (up to the concentration of the drilling fluid itself) but will have a correspondingly small footprint. The plume will subsequently be advected in the general direction, and at the speed of, the ambient currents at the time of the release, and will become gradually dispersed, both horizontally and vertically, by the natural process of diffusion. The results are shown in Figure 2-14 to Figure 2-17 for spring tides; in Figure 2-18 to Figure 2-21 for neap tides; and summarised in section 2.5.4.

2.5.2 HDD During Spring Tide Conditions

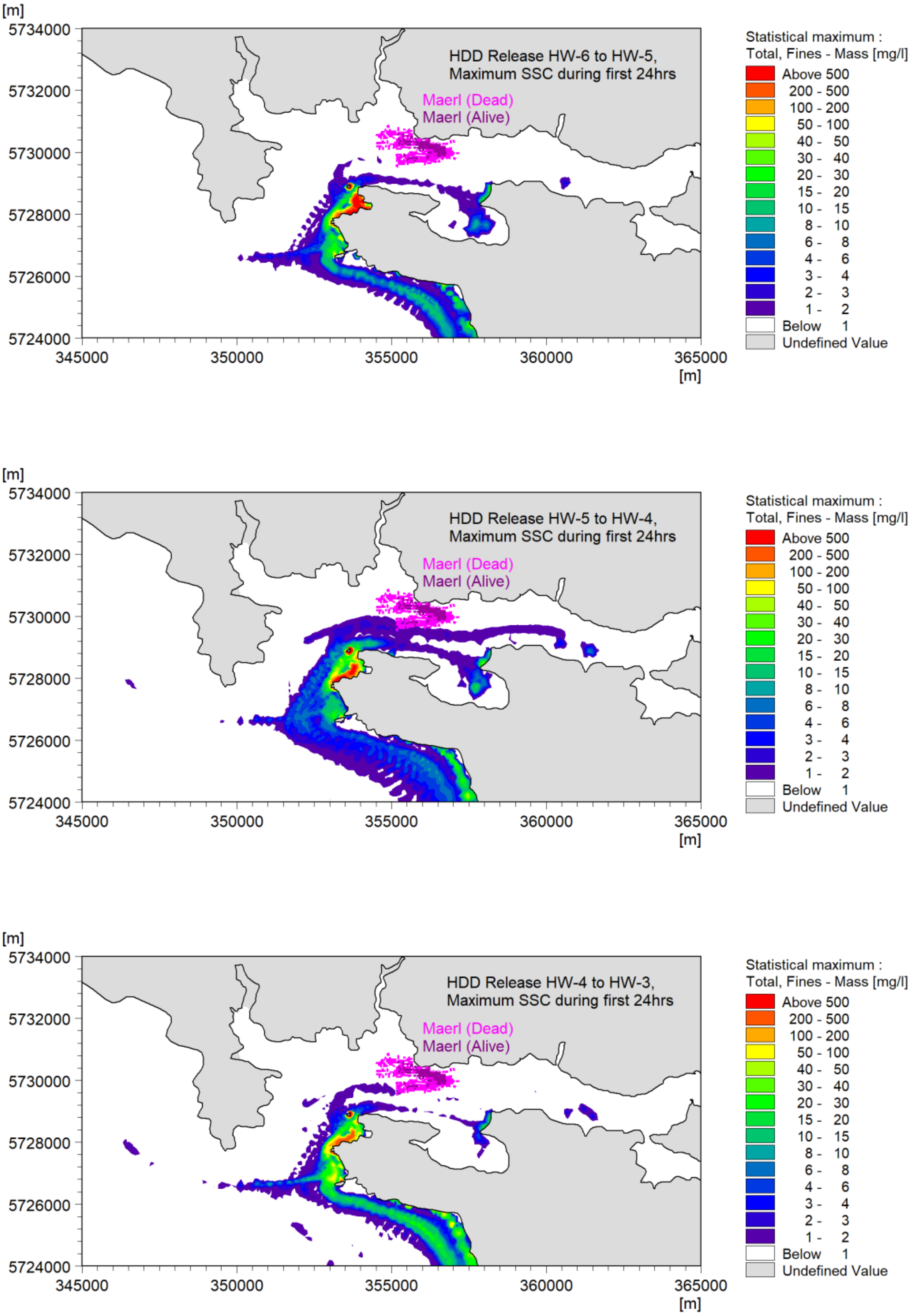


Figure 2-14: Maximum local SSC at any time during HDD activities on spring tides, starting at HW 6 (approximately low water slack) to HW-4.

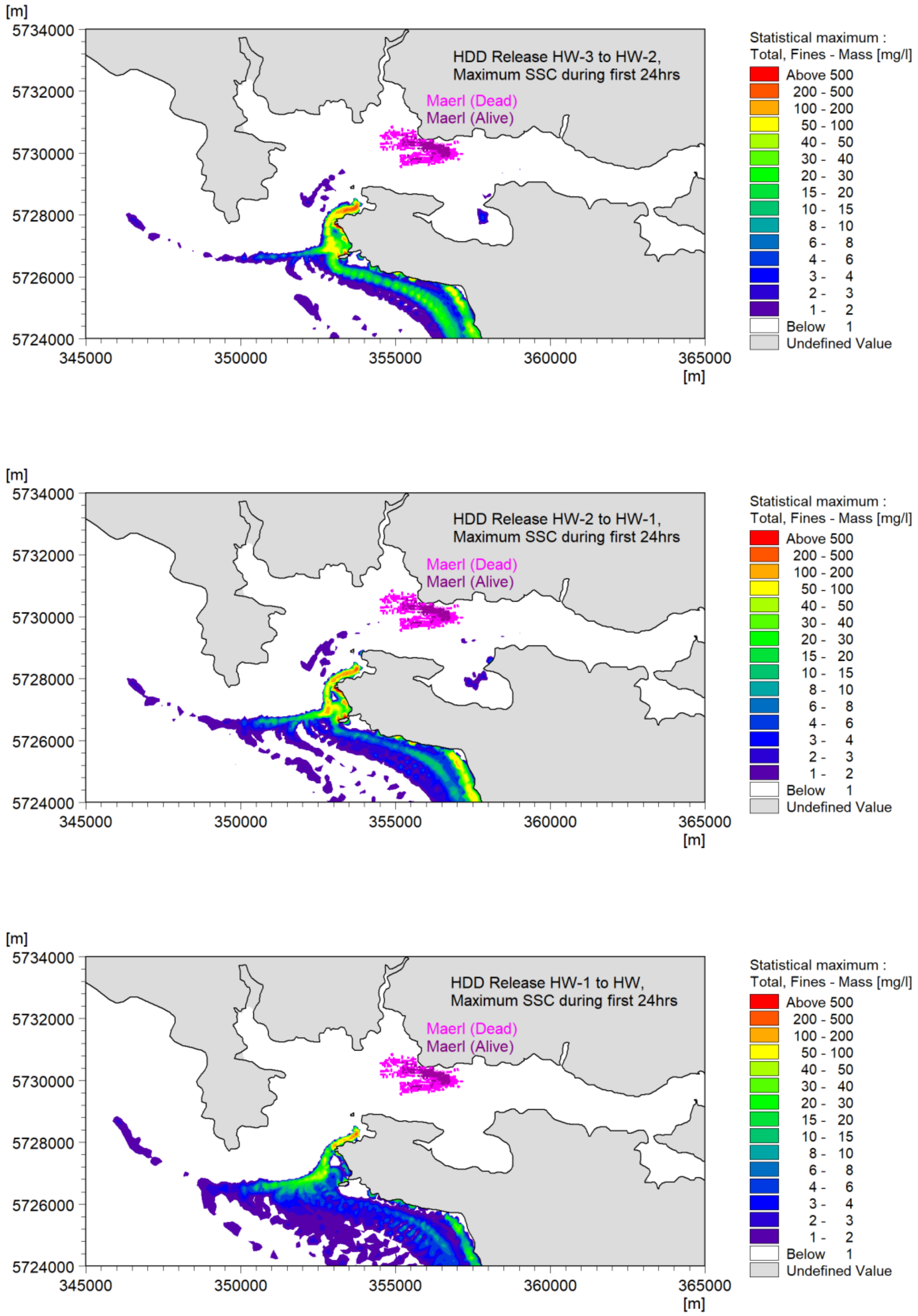


Figure 2-15: Maximum local SSC at any time during HDD activities on spring tides, starting at HW-3 (approximately peak flood tide) to HW-1.

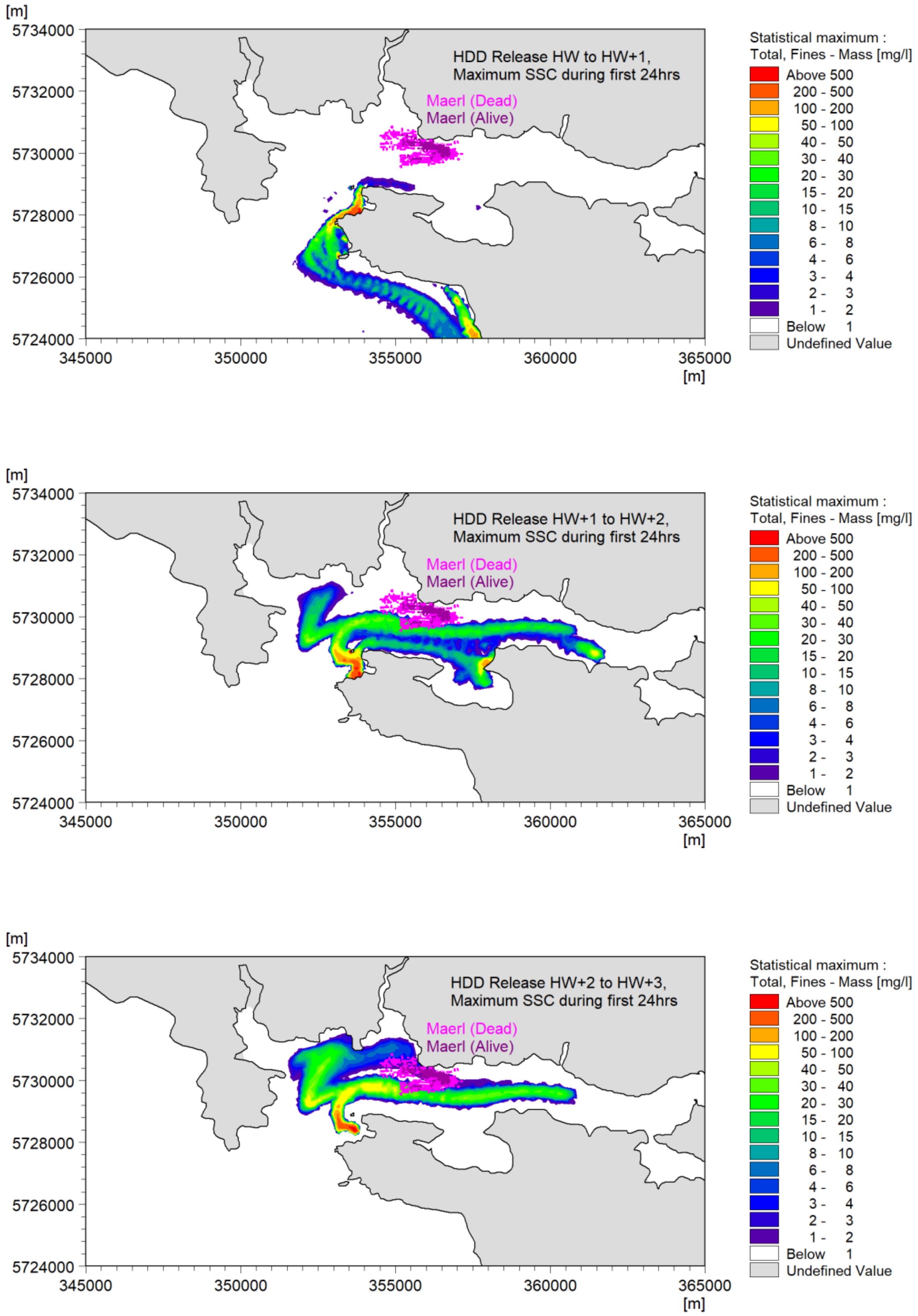


Figure 2-16: Maximum local SSC at any time during HDD activities on spring tides, starting at HW (approximately high water slack) to HW+2

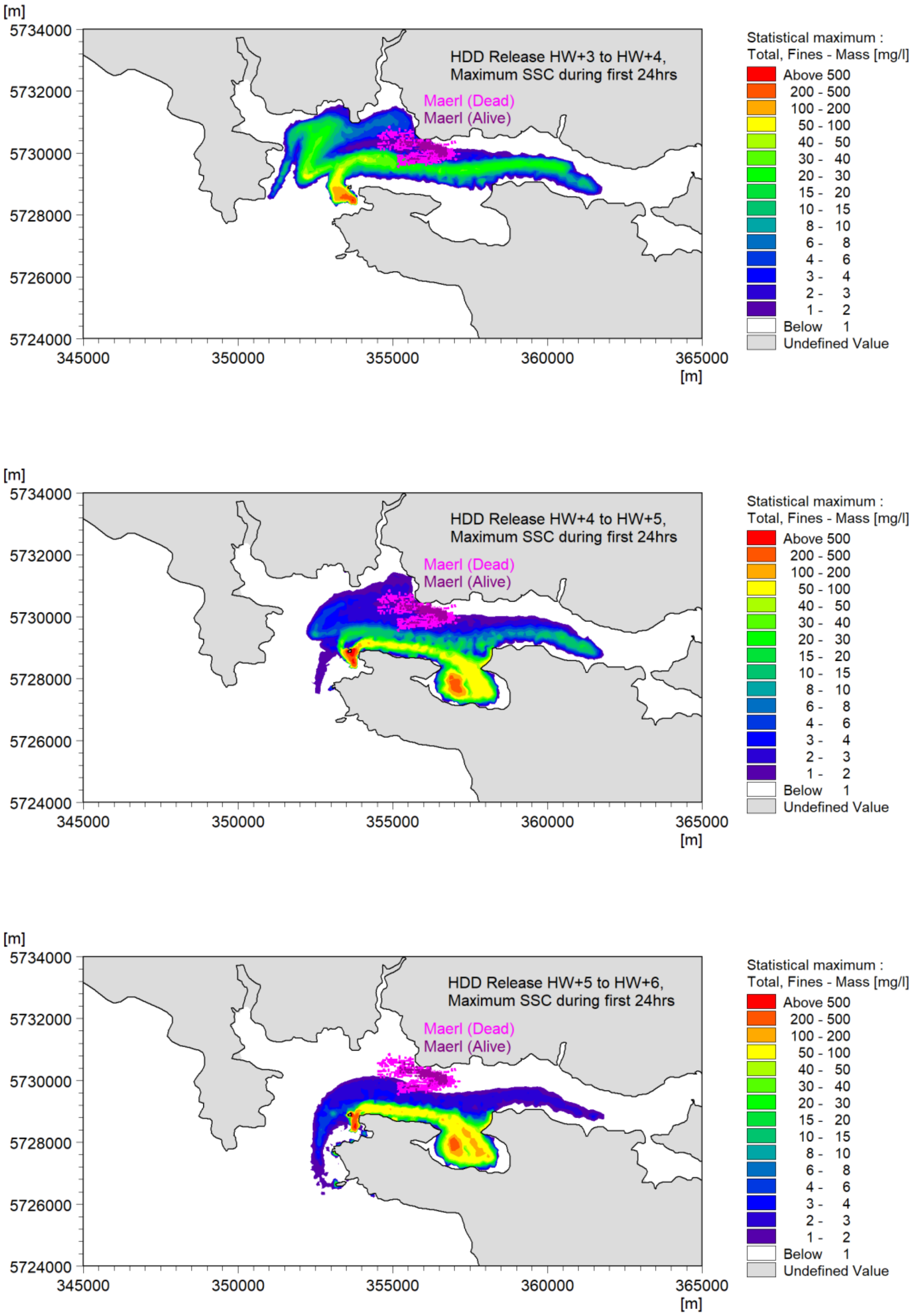


Figure 2-17: Maximum local SSC at any time during HDD activities on spring tides, starting at HW+3 (approximately peak ebb tide) to HW+5

2.5.3 HDD During Neap Tide Conditions

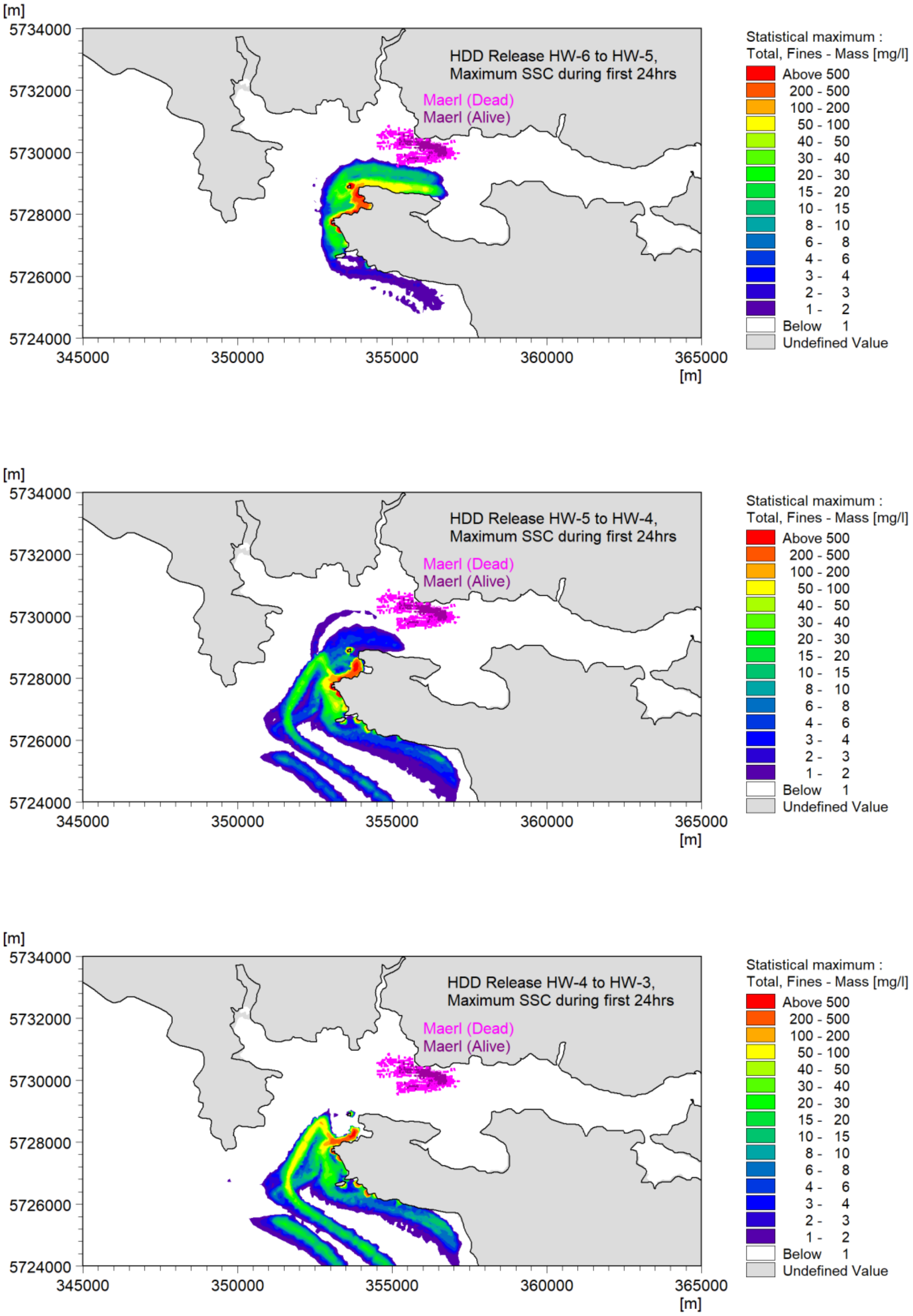


Figure 2-18: Maximum local SSC at any time during HDD activities on neap tides, starting at HW-6 (approximately low water slack) to HW-4.

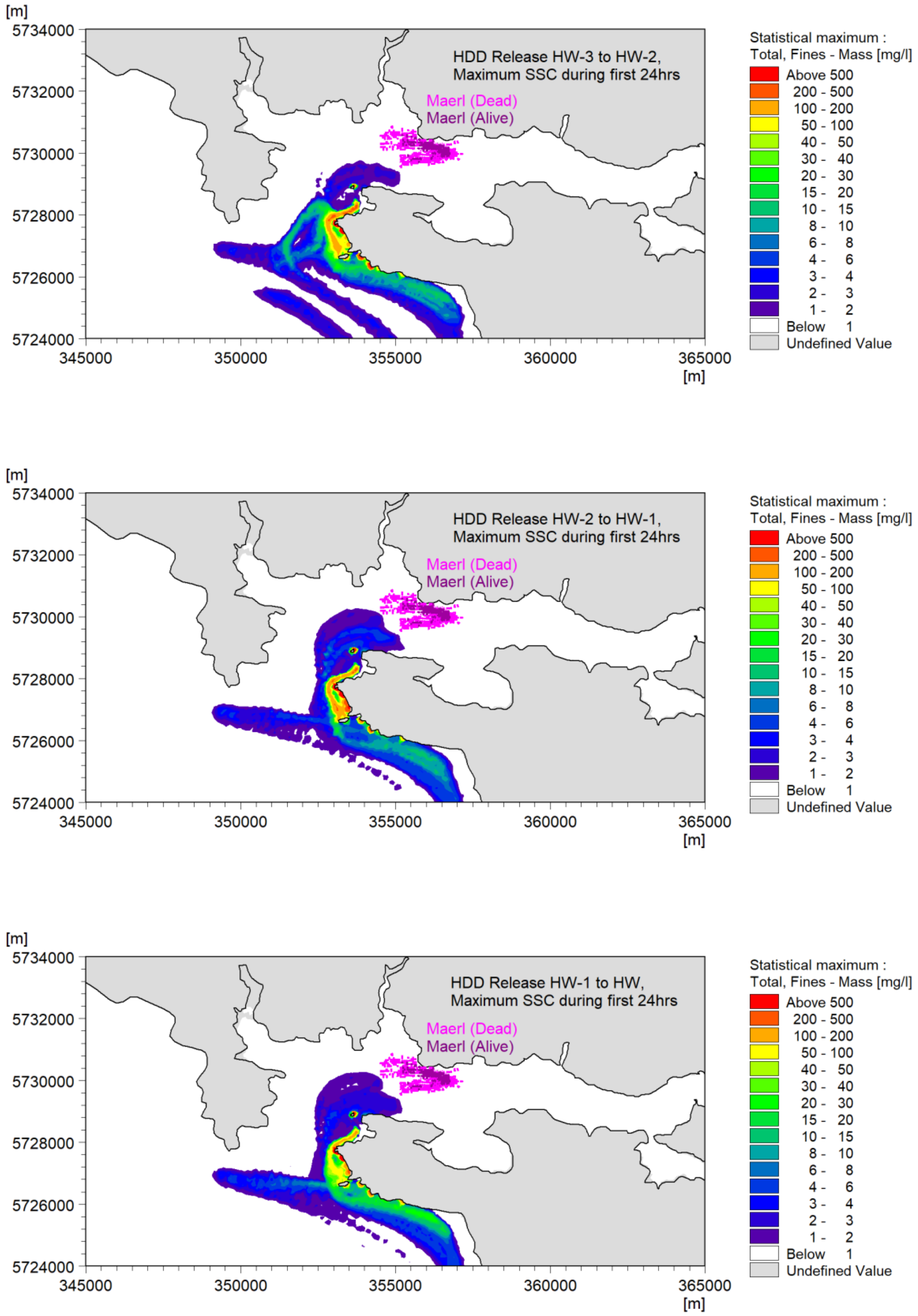


Figure 2-19: Maximum local SSC at any time during HDD activities on neap tides, starting at HW-3 (approximately peak flood tide) to HW-1.

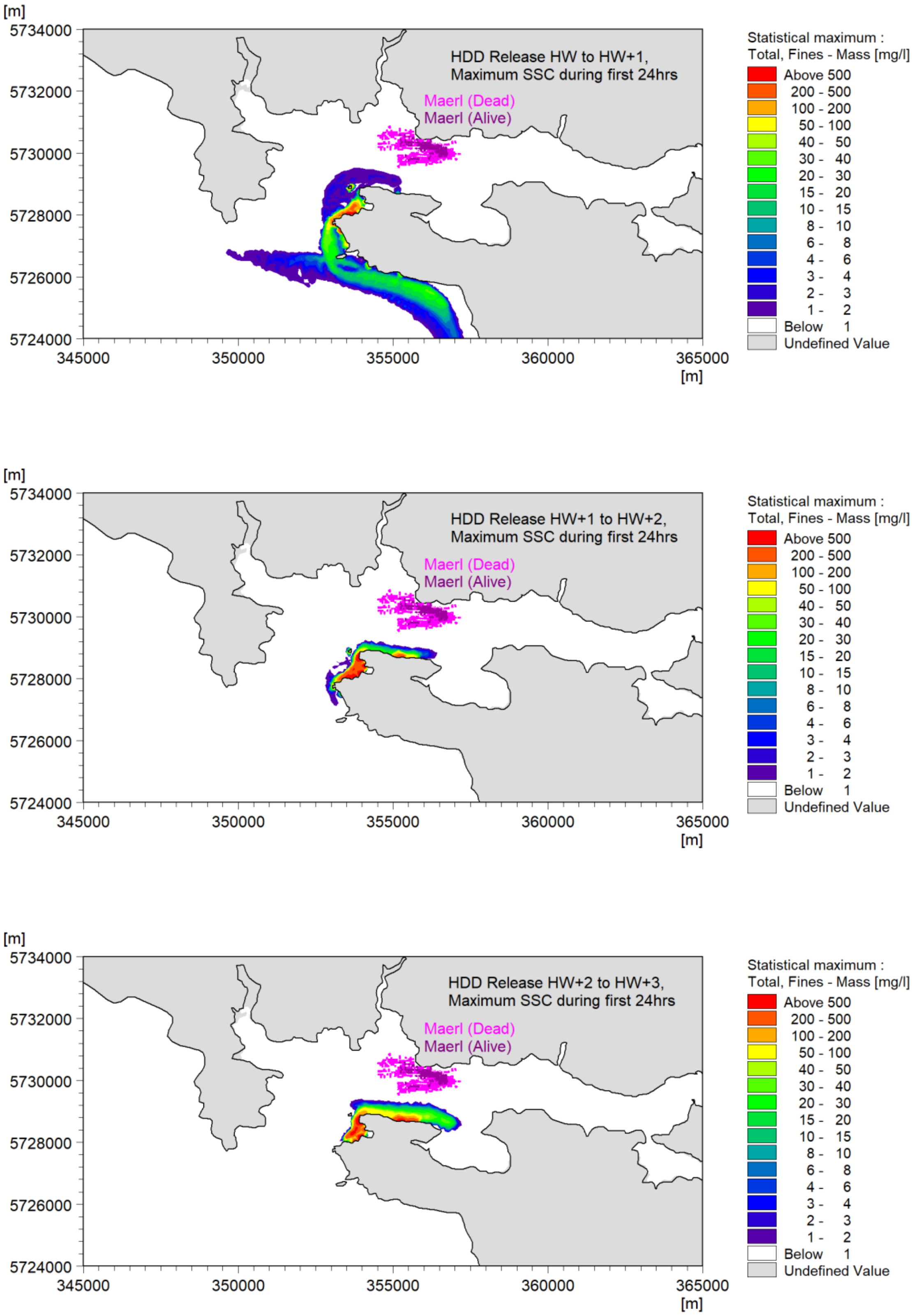


Figure 2-20: Maximum local SSC at any time during HDD activities on neap tides, starting at HW (approximately high water slack) to HW+2

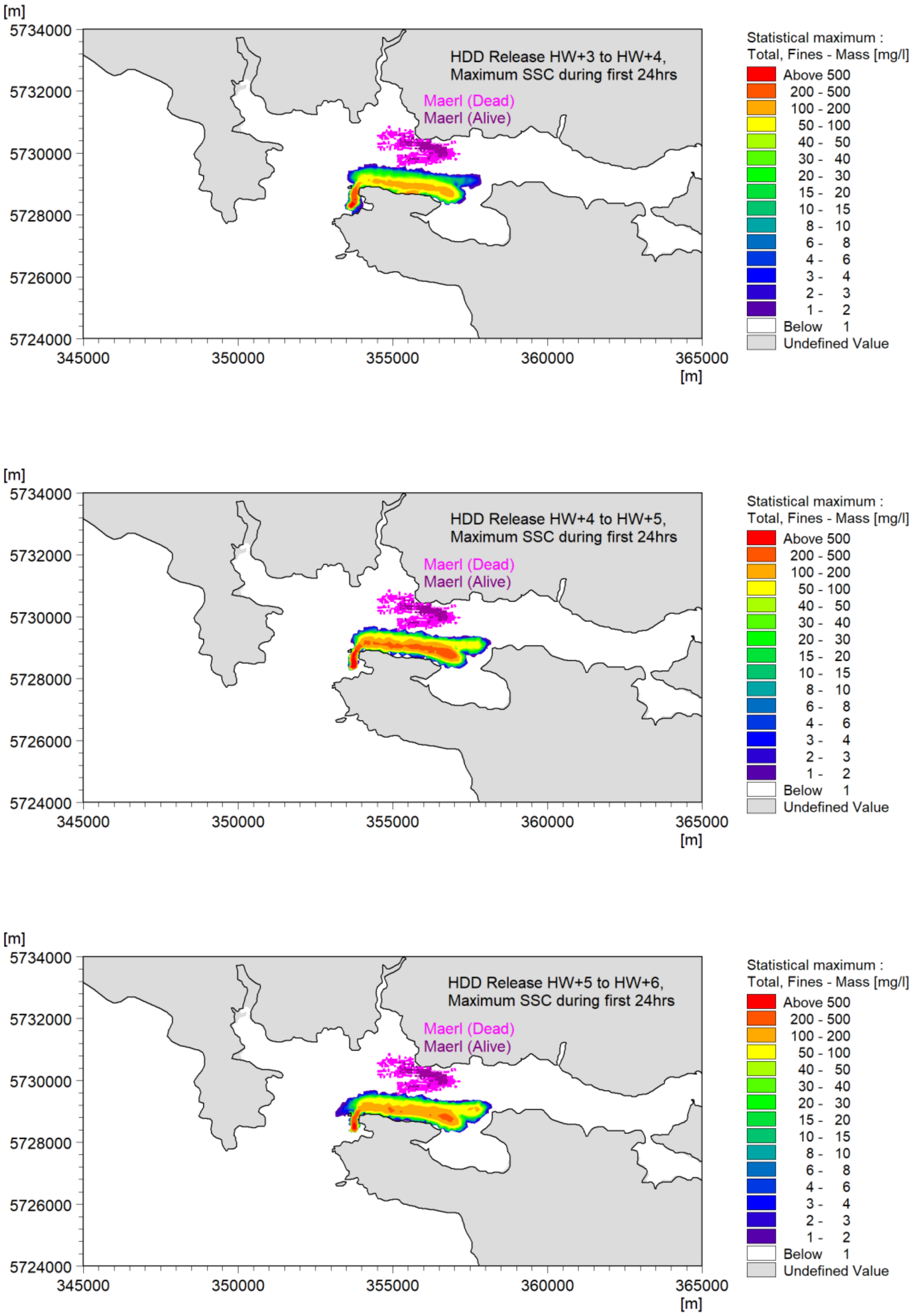


Figure 2-21: Maximum local SSC at any time during HDD activities on neap tides, starting at HW+3 (approximately peak ebb tide) to HW+5

2.5.4 Summary

2.5.4.1 The main findings of the new fine sediment plume modelling for drilling fluid release during HDD at the landfall in West Angle Bay can be summarised as follows:

- Under spring tidal conditions, fine sediment suspended by HDD punch out and release of drilling fluid in West Angle Bay can cause a weak sediment plume to extend into the estuary and overlap with the known location of Maerl beds;
  - The maximum modelled increase in SSC within the area of live Maerl beds is approximately 30 mg/l, however this peak effect is only briefly observed (order of 10 minutes) in a limited number of cases (see below);
  - Modelled increases in SSC within the area of live Maerl beds are more typically limited to less than 10 mg/l, lasting for approximately 1 to 4 hours, for 5 of the 12 release timing scenarios (starting in West Angle Bay between HW+1 and HW+5, approximately during the ebb tide period). This occurs because plumes arising in and close to West Angle Bay during these tidal periods are somewhat contained and restrained by the naturally low local current speeds. By the time the sediment plume reaches the main channel flow (several hours later), the remainder of the ebb tide encourages dispersion across the estuary width. The following flood tide then transports the plume into the estuary far enough to overlap the Maerl beds;
  - Modelled increases in SSC within the area of live Maerl beds are negligible or zero at any time for 7 of the 12 release timing scenarios (starting in West Angle Bay between HW-6 and HW, approximately during the low water slack, flood tide, and high water slack period). This occurs because plumes arising in West Angle Bay during these tidal periods are somewhat contained and restrained by the naturally low local current speeds. By the time the sediment plume reaches the main channel flow (several hours later), the flood tide is at least partially complete, so does not then transport the plume far enough into the estuary to overlap the Maerl beds. The following ebb period then tends to drive the plume out of the estuary and disperse it offshore;
- Under neap tidal conditions, modelled increases in SSC within the area of live Maerl beds are negligible or zero at any time for all of the 4 release timing scenarios;
  - The tidal current excursion distance is sufficient to advect the sediment plume to the near vicinity of the Maerl beds, however, the different patterns of current speed and direction confine the plume to the main channel to the south;
  - Similar release timing effects to those described above for spring tidal conditions are also noted;
- Sediment deposition thickness in and around the area of the live and/or dead Maerl beds (not plotted) is predicted to be <1 mm (<20 g/m²) in all cases, which is not measurable in practice and will be, at most, comparable to normally occurring patterns as a result of natural processes and other vessel movement related disturbances;
- Additional information related to the potential ecological aspects of the above conclusions are presented in Section 3: Marine and Coastal Ecology.

2.6 Potential Impact of Cable Protection on Sediment Transport Affecting Turbot Bank

2.6.1 Introduction

2.6.1.1 In the statutory consultee response to the Project ES, NRW Advisory raised the following specific query relating to the assessed effects of external cable protection on sediment transport in the vicinity of Turbot Bank. The following section provides a more detailed response to this query.

NRW Advisory Comment

ES Vol. 1 Ch.6 Table 6.18 and ES Vol. 2 Figure 6.1 identifies that Annex 1 sand bank occurs in the SAC within and around the ECC at Turbot Bank (KP6.5 to 10.5) and within and around the ECC at KP 14.7 – KP17.7 outside the SAC… The sand bank at KP14-7 – KP 17.7 is potentially an Annex 1 habitat outside the SAC… We agree that in isolation, the small section of cable protection between KP7.1 and 7.3 (200m) will unlikely cause any changes to waves, tides and sediment transport and accordingly, no morphological change to the Turbot Bank is expected to occur with the cable protection in place (ES Vol. 1 Ch. 6 section 6.6.3.18). However, no consideration has been given to the impact that the two longer sections of cable protection detailed in ES Vol. 2 Figure 6.16 north and south of the Turbot Bank, and the cable protection proposed north and south of the sand bank system located at KP14.7 to KP 17.7, will have on the clockwise bedload sediment transport pathways and whether they could potentially impact on the morphological form and function of the Annex 1 sand bank systems over the operational phase of the Project. Until these assessments are carried out, we cannot agree that the cable protection will not cause a significant environmental impact to morphological form and function of the Annex 1 Sand Bank feature of the Pembrokeshire Marine SAC and the Annex 1 sand bank outside the SAC.

2.6.2 Potential changes to the morphology of the seabed including from scour (receptor: Turbot Bank)

2.6.2.1 The assessment in the Project ES utilises modelled patterns of sediment transport, which describe a spatially complex pattern near and around Turbot Bank. The conclusions of the assessment are based partially on the lack of direct linkage (in terms of sediment transport pathways) between Turbot Bank and areas of seabed where external cable protection rock berms might be present. This point is illustrated in a more direct manner in Figure 2-22.

2.6.2.2 The assessment also notes that the eternal cable protection rock berms fundamentally have little to no potential to block or otherwise change the magnitude or direction of long-term sediment transport locally, or regionally elsewhere, indirectly through changes to patterns of currents or waves.

2.6.2.3 The results of this assessment, and the scope for additional assessment was discussed with NRW Advisory in a subsequent Expert Topic Group (ETG) meeting (25 May 2022).

2.6.2.4 During this meeting, it was agreed that the existing assessment provided a reasonable theoretical conclusion on the basis of the available evidence. Remaining uncertainty in the details of the final impact description relate to the baseline understanding of sandwave migration rates on Turbot Bank (ideally requiring additional historical survey data, which do not exist, to our knowledge) and the finer detail of sediment transport pathways and linkages in the wider area (presently supported by regional tidally driven sediment transport modelling).

2.6.2.5 It was also agreed that there are no other additional data sources, and no obvious other assessment approaches that could provide a more robust assessment than that already provided.

2.6.2.6 We have reviewed the basis and conclusions of the original assessment, accounting for the comments regarding uncertainty above. It is our expert opinion that the existing assessment and findings are sufficient to describe the potential level of impact and therefore properly informs the EIA and HRA. We trust it is understood, and agreed, that no fundamentally new evidence or assessment can be offered at this time. However, as set out within the Project ES and the Outline Environmental Monitoring Plan (OEMP), (prepared post ES submission and included as part of this submission of supplementary information), the Applicant (BGW) is committed to undertaking pre- and post-installation bathymetric surveys of the ECC, with a particular focus on areas of specific interest. Such areas include the section of the ECC that passes close to Turbot Bank, therefore, future monitoring of this area will provide further data to inform this issue and validate the predictions of this assessment.

2.6.2.7 Potential impacts on Turbot Bank, as a whole, have been assessed in Project ES Volume 1 Chapter 6: Marine and Coastal Processes. The assessment considers the nature, magnitude, extent and duration of any effect on the seabed and sediment supply, from any part of the Project infrastructure, potentially affecting any part of the Bank. The designation status of any particular area of seabed, or any nominal perimeter of the Bank extent, is not relevant to the physical basis of the assessment. The designation status of the Bank is accounted for in the description of the receptor, and the conclusion regarding significance of the impact.

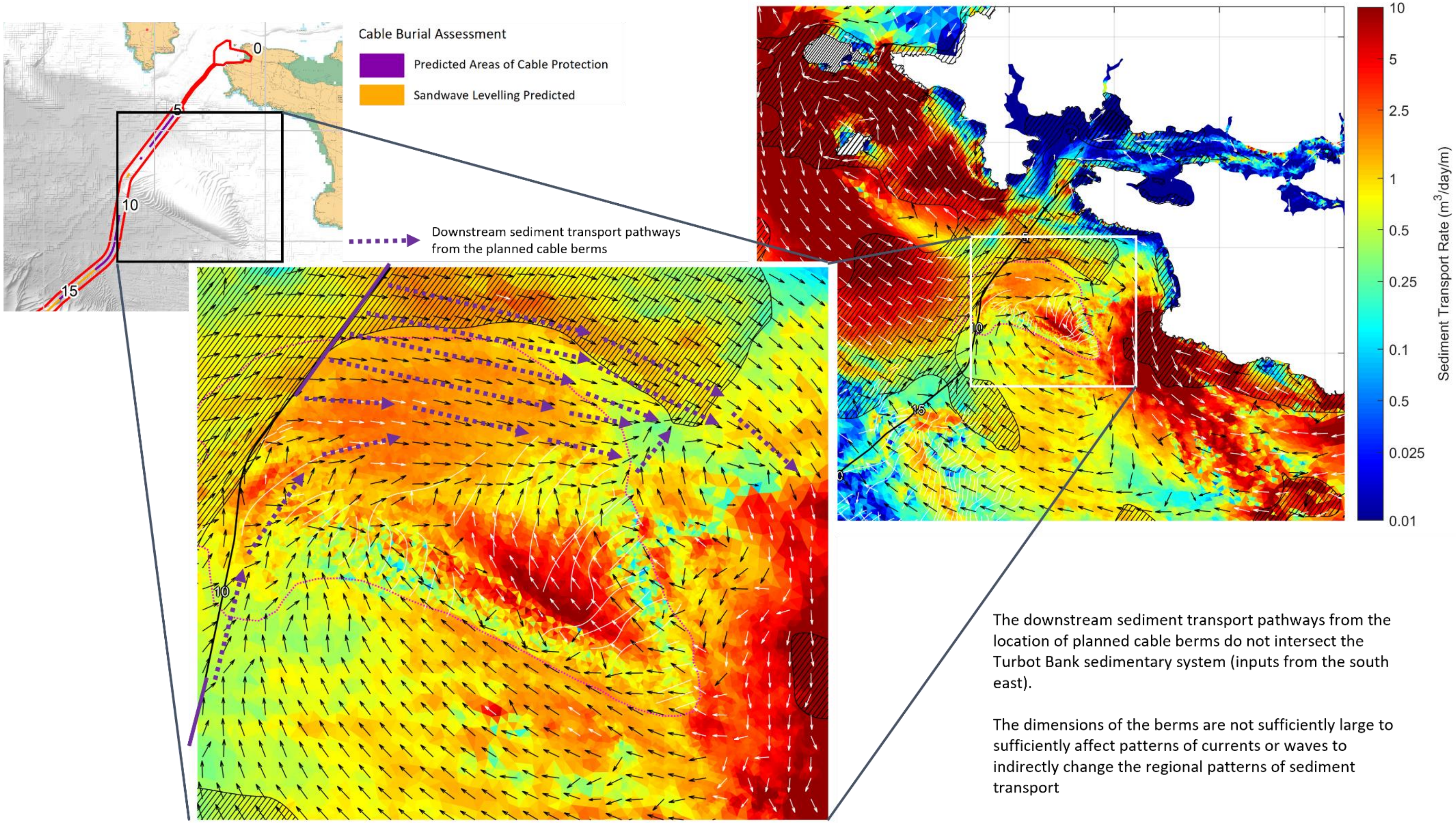


Figure 2-22: Predicted patterns of long term sediment transport pathways in nearshore areas and detail around Turbot Bank.

2.7 Rates of bedform recovery following localised levelling disturbance

2.7.1 Introduction

2.7.1.1 In the statutory consultee responses to the Project ES, NRW Advisory raised the following specific query relating to the assessed expected rates of bedform recovery following levelling disturbance during cable burial. The following section provides a more detailed response to this query.

NRW Advisory Comment

ES Vol. 1 Ch. 6 Table 6.19 and Vol. 2 Figure 6.12 shows the locations along the ECC where sand wave levelling is proposed. Particular attention has focussed on areas KP 8.0-8.5, 12.5-13, 13.5-14, 15-15.5 and 15.5 – 16.5 which is within the SAC sites. The magnitude of impact to the seabed resulting from sand wave levelling has been considered to be low. ES Vol. 1 Ch. 6 Section 6.6.2.34. The magnitude of impact has been assessed based on an assumption that the seabed will recover in response to short term seabed mobility driven by the short-term peak flood and ebb currents (note that the resultant maps of the instantaneous potential sediment transport rates were not presented (ES Vol. 1 Ch. 6 section 6.5.12.2)). Sand wave migration will also be influenced by waves, particularly in shallower locations. Given the uncertainties in the assessment of impact caused by sand wave levelling and the insufficient bathymetric data coverage, the rate of sand wave recoverability has not been adequately assessed and as a result we have low confidence with the magnitude of impact being assessed as low. ES Vol. 1 Ch. 6 Table 6.6 defines Low Magnitude as "Noticeable, temporary change (for part of the Project duration), or barely discernible change for any length of time, restricted to the near-field and immediately adjacent far-field areas, to key characteristics or features of the particular environmental aspect's character or distinctiveness". It is based on a semantic scale and not on time scales. Potentially, sand waves could take many years to recover or potentially never recover. We advise that a precautionary approach is taken in this case and that the magnitude of impact to be assessed as medium until further evidence has been presented which can quantify the recoverability of the sand wave features to be considered as low magnitude.

There is insufficient high resolution baseline bathymetry data to determine the migratory rate of sand wave features that is a requirement in determining the recovery rate of sand waves following sand wave levelling which is proposed along the ECC and Array in the process of cable laying. These limitations and the resultant uncertainties are highlighted in ES Vol. 1 Ch.6 section 6.4.13.1 and in section 6.6.2.28. It is acknowledged that the migratory rates of sand waves in the northern section of the Array are very low and stable (ES Vol.1 section 6.5.15.11). Potentially, the sand waves in the Array may never recover following sand wave levelling. However, the sand waves are outside any designated areas and we welcome that further monitoring through bathymetric surveys will be conducted pre-construction and at years 1, 5 and 10 following construction to determine the rate of recovery if at all. The further evidence collected will also inform future FLOW Projects which are proposed in the Celtic Sea

2.7.2 Potential changes to the morphology of the seabed including from scour (receptor: sandwaves in designated areas)

2.7.2.1 Where available (Figure 2-23), repeat historical bathymetric data sets of sufficient quality, have been used in the Project ES to estimate the migration rate of larger bedforms such as sandwaves. The quantity (coverage and number of surveys) and the quality (spatial resolution) of the repeat surveys was variable in the offshore array area and along the ECC, but was generally sufficient to make a reliable measurement in most key locations. The relative rates of migration (including areas of stationary bedforms) are consistent with the maps of net sediment transport magnitude created for the Study Area (e.g. Figure 2-22), which validates this source of evidence, in order to infer general sediment mobility magnitude, and the likelihood of bedform migration in other locations.

2.7.2.2 As there is only one suitably high-resolution historical survey available for Turbot Bank, it was not, and is still not, possible to make direct measurements of bedform migration rate over the whole area of the Bank. However, we feel it is reasonable to conclude that these features are mobile to some extent (enabling long-term recovery), based on the characteristic shape and asymmetry of the contemporary features (e.g. Figure 2-24 and Figure 2-25) in conjunction, and consistent, with the regionally validated sediment transport model results (e.g. Figure 2-22).

2.7.2.3 We therefore suggest that the evidence base regarding the measured rate of bedform migration, or the inferred likelihood of migration in the absence of a measured rate, is suitably reliable and extensive over the whole relevant part of the study area.

2.7.2.4 With respect, for the following reasons, no change has been made to the assessed magnitude of impact (Low) or the conclusion of impact significance (minor adverse) for this assessment.

2.7.2.5 This specific comment from NRW Advisory, and the related descriptions/assessments of sediment mobility and bedform migration on and around Turbot Bank, have been discussed further in a subsequent Expert Topic Group (ETG) meeting (25 May 2022). As summarised above, those discussions established that the remaining uncertainty relates mainly to certain detailed or quantitative descriptors of sediment mobility (e.g. the relative contribution of waves) and bedform mobility (observed migration rates are not possible in the absence of more data) on and around Turbot Bank.

2.7.2.6 Based on the shape of the contemporary features, and the regionally validated sediment transport model results, it was agreed that sediment on and around Turbot Bank is likely to be naturally mobilised on a regular basis, and that the bedforms present are likely to be migrating measurably on the timescale of the Project (therefore providing the mechanisms for recovery over time).

2.7.2.7 Based on our judgement and the available evidence, we therefore assess that bedforms subject to localised levelling, on or near Turbot Bank, are likely to recover over time, and within a timeframe up to the operational lifetime of the Project.

2.7.2.8 As such, we feel that the magnitude of the potential impact is correctly identified as 'Low', defined as [*Noticeable, temporary change (for part of the Project duration), or barely discernible change for any length of time, restricted to the near-field and immediately adjacent far-field areas, to key characteristics or features of the particular environmental aspect's character or distinctiveness*].

2.7.2.9 The definition of a 'Medium' magnitude of impact includes [*Permanent changes, over the near- and parts of the far-field…*], which is not suggested as likely by the assessment, even including allowance for any remaining uncertainty. Therefore, it is our view, as the EIA topic lead, that increasing the magnitude of impact to Medium, cannot be justified in this case.

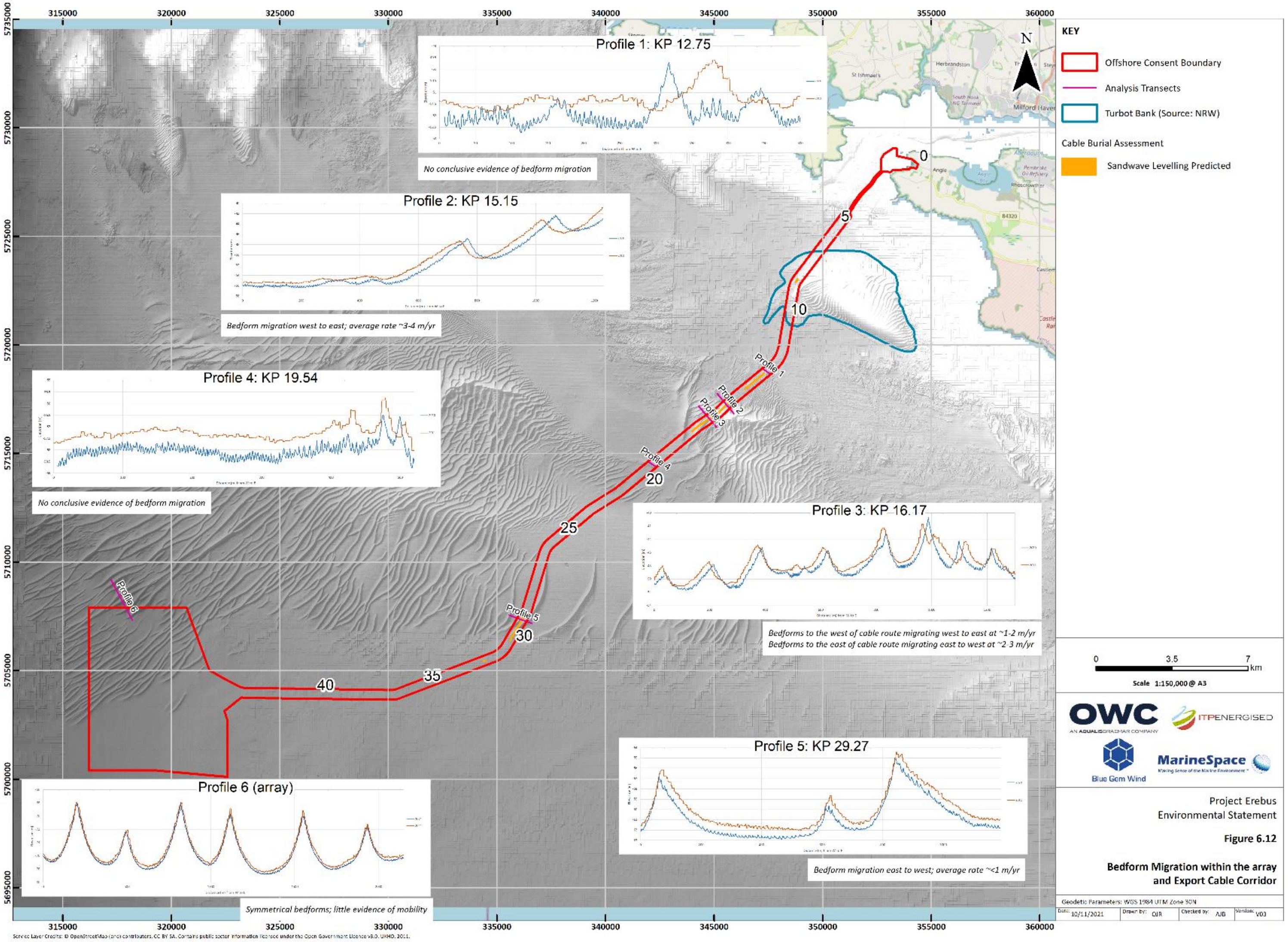


Figure 2-23: Bedform migration rates within the array and export cable corridor

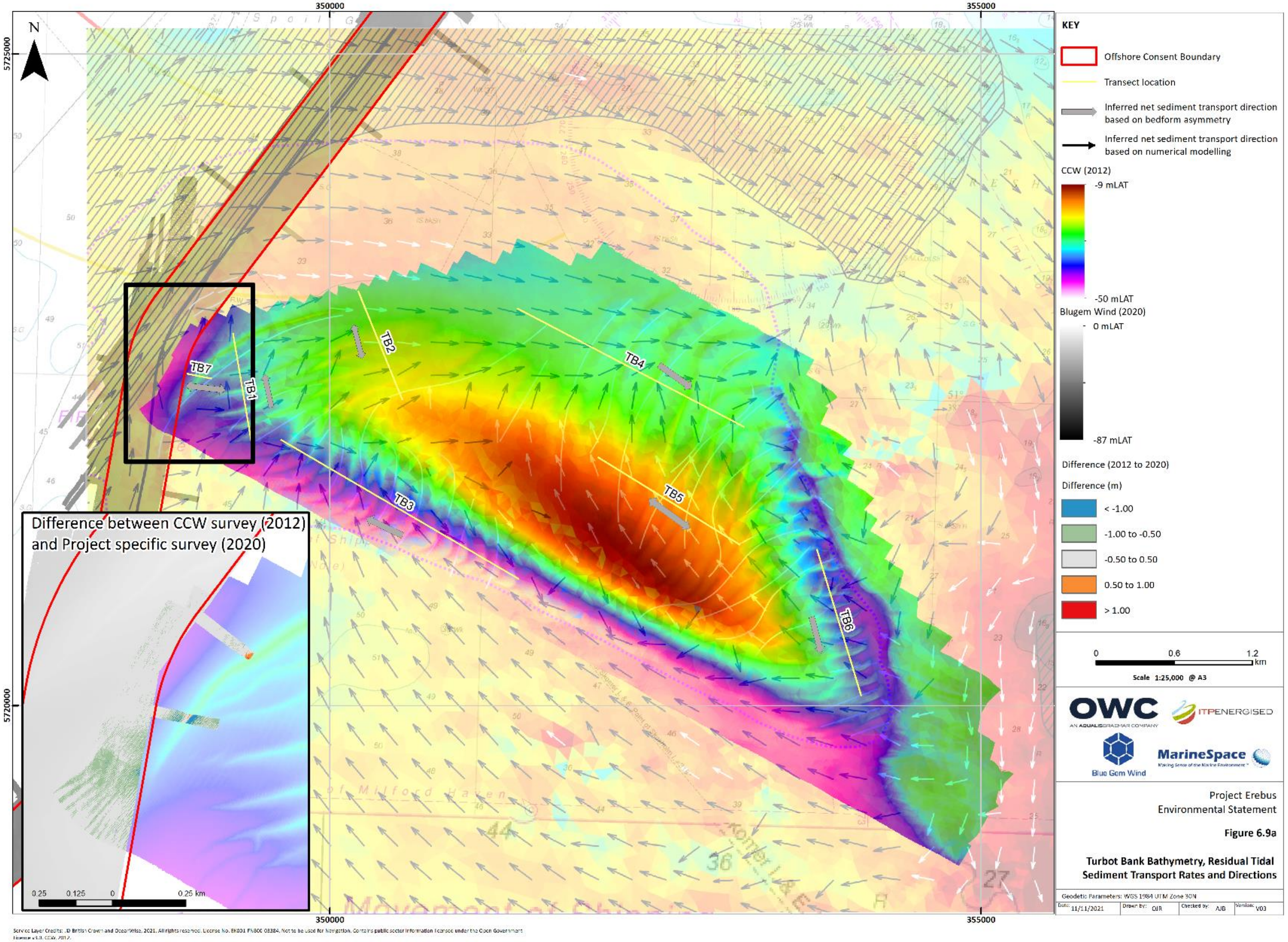


Figure 2-24: Turbot Bank bathymetry, residual tidal sediment transport rates and directions

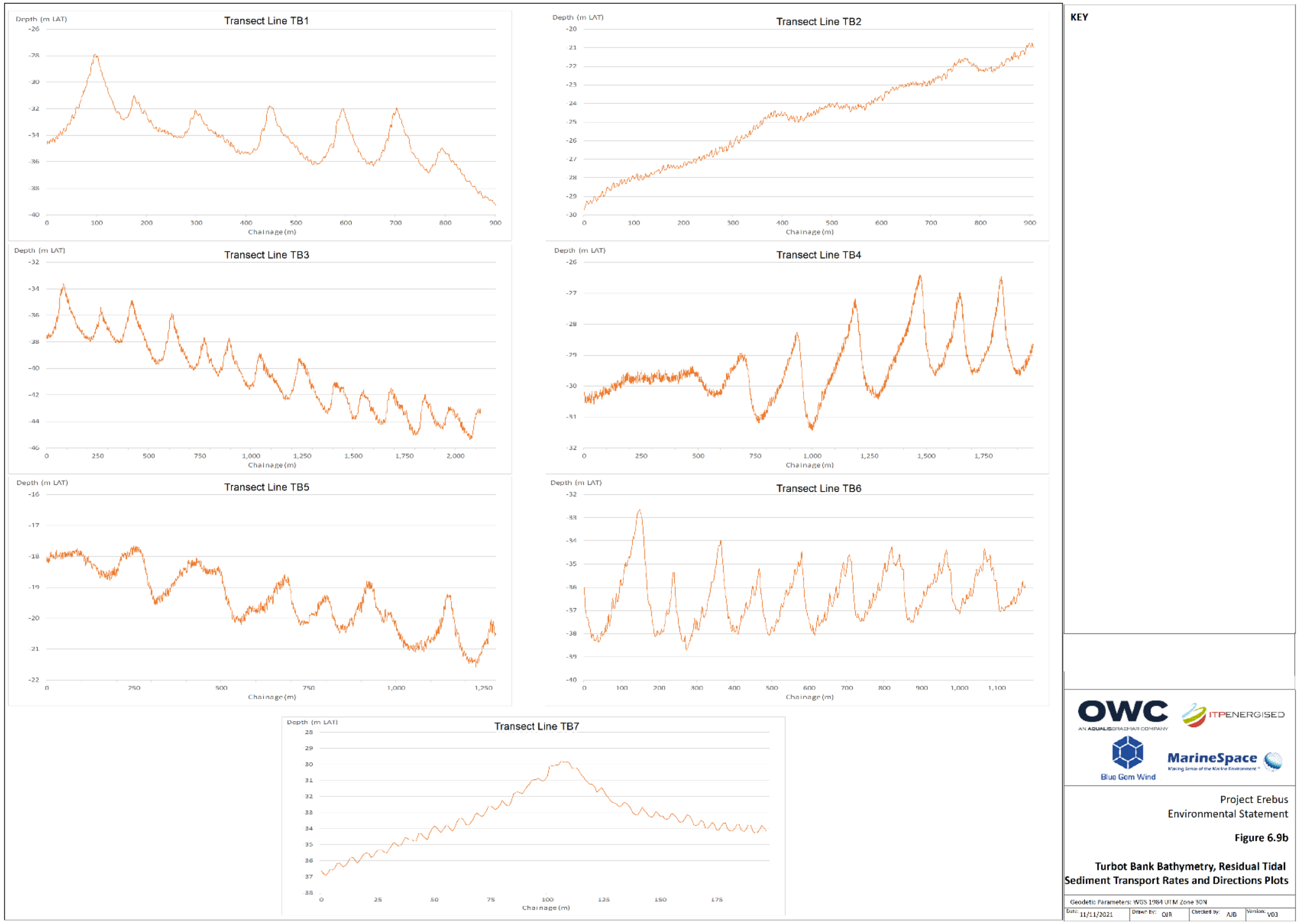


Figure 2-25: Bathymetric cross sections of Turbot Bank (see Figure 2-24)

Chapter 3 Marine and Coastal Ecology

3.1 Scope

3.1.1.1 This chapter has been prepared in response to specific queries raised by Natural Resources Wales (NRW) Advisory and Joint Nature Conservation Committee (JNCC), via their formal response to the Project Environmental Statement (ES) Volume 1 Chapter 9: Marine and Coastal Ecology.

3.1.1.2 This chapter is to be read in conjunction with the corresponding ORML270 Technical and General Consultation Responses SEI Response spreadsheet.

3.1.1.3 The key points raised by NRW Advisory in its responses related to the following:

- The extent of Annex I habitat features in the Sir Benfro Forol/Pembrokeshire Marine Special Area of Conservation (SAC);
- Potential impacts on Annex I sandbank habitat (Turbot Bank) via external cable rock protection;
- The potential impact of fine sediment plumes on Maerl beds in the Milford Haven Waterway;
- Potential impacts on Annex I habitat features via landfall works at West Angle Bay;
- The potenital impacts of sediment plumes on sea caves of the Arfordir Calchfaen de Orllewin Cymru/Limestone Coast of South West Wales SAC;
- Assessment of *Sabellaria spinulosa* Annex I biogenic reef;
- Classification of Annex I subtidal sandbanks;
- Introduction and colonisation by invasive non-native species (INNS);
- Colonisation of infrastructure by native species; and
- The potential cumulative effects of the Project and future climate pressures on benthic ecology.

3.2 Extent of Annex I habitat features in the Pembrokeshire Marine/Sir Benfro Forol Special Area of Conservation

3.2.1 Data Sources

3.2.1.1 We confirm that there was a discrepancy between the spatial extent of Annex I habitat features of the Pembrokeshire Marine/Sir Benfro Forol Special Area of Conservation (SAC) presented in the ES Volume 1 Chapter 9: Marine and Coastal Ecology and Volume 3 Technical Appendix 8.3: Habitats Regulations Assessment Report to Inform Appropriate Assessment (RIAA).

3.2.1.2 Within the ES Volume 1 Chapter 9: Marine and Coastal Ecology, all values cited for the extent of Annex I habitat features within the Pembrokeshire Marine SAC were sourced from the Lle Geo-Portal (Lle Geo-Portal, 2022). The shapefiles exported from the Lle Geo-Portal, had been used in all relevant maps in the chapter and this data source had been referenced throughout the chapter.

3.2.1.3 Within the RIAA, all values cited for the extent of Annex I habitat features were sourced from the Standard Data Form (JNCC, 2015a). The Standard Data Form was first compiled in October 1997, and the version used in the RIAA was the latest update, dated December 2015.

3.2.1.4 Within the ES Volume 1 Chapter 9: Marine and Coastal Ecology (Section 9.6.5 Annex I Interaction Summary; paragraphs 9.6.5.1-9.6.5.2), there is reference to the two different data sources used to inform the assessments in the ES, and the RIAA.

3.2.1.5 MarineSpace sought clarification from NRW Advisory, by email on 08 June 2022, as to whether calculations in the assessments are to be based on the Lle Geo-Portal (as used in the ES), or the JNCC Standard Data Form (as used in the RIAA).

3.2.1.6 NRW Advisory responded by email on 14 June 2022, confirming that the figures from the Lle Geo Portal are to be used (as presented in the ES), as these are the most up to date.

3.2.1.7 Therefore, the confirmed spatial extents for the relevant Annex I habitat features are listed in Section 3.2.2 below, and as cited in the ES, have been sourced from the Lle Geo-Portal.

3.2.2 Extent of Annex I Reef Extent

3.2.2.1 The spatial extent of Annex I reef (geogenic) within the Pembrokeshire Marine SAC is **444.68 km^2**. This is represented by **433.15 km^2** subtidal reef and **11.53 km^2** intertidal reef.

3.2.3 Extent of Annex I Subtidal Sandbank

3.2.3.1 The spatial extent of Annex I sandbanks which are slightly covered by seawater all the time (hereafter referred to sandbanks), within the Pembrokeshire Marine SAC is **51.59 km^2**.

3.2.4 Extent of Annex I Intertidal Mudflats and Sandflats

3.2.4.1 The spatial extent of Annex I intertidal mudflats and sandflats within the Pembrokeshire Marine SAC is **19.01km^2**.

3.3 Annex I Sandbank Turbot Bank and External Cable Protection

3.3.1 Overview

3.3.1.1 This section considers the potential effect on the Annex I sandbank Turbot Bank of the placement of external cable rock protection proposed for nearby sections of the export cable corridor (ECC). Following the formal consultation responses from NRW Advisory, further clarifications and updated assessments had been requested, regarding the assessment presented in the ES, that considered potential impacts of this external cable protection on the form and function of Turbot Bank.

3.3.1.2 Section 3.3.2 confirms the total area of footprint of external cable rock protection at the Greenlink interconnector cable crossing that is proposed near the Turbot Bank Annex I sandbank, and provides an updated assessment on the long-term habitat loss on this feature produced by the proposed external cable rock protection.

3.3.1.3 Section 3.3.3 considers the potential impact of external cable rock protection to the north and south of Turbot Bank, in combination with the Greenlink cable crossing, on the morphology of Turbot Bank (see ES Volume 2 Figure 9.13b).This has been informed and supported by the assessments undertaken by ABP, reported in Section Chapter 2 of this SEI document.

3.3.2 Greenlink Cable Crossing

Footprint of Cable Rock Protection

3.3.2.1 The Applicant acknowledges that there was a discrepancy between the amount of cable protection presented in the ES and the RIAA.

3.3.2.2 For the ES, the values had been derived from the Project Design Envelope (PDE), where the total area was based on 120-150 m length, and 10-14 m width. This resulted in a worst-case, 150 x 14 m = **2,100 m²** (**0.0021 km²**).

3.3.2.3 For the RIAA, the values had been derived from the Seabed Intervention Sheet, where the footprint of rock was defined as **559.7 m²** (**0.00059 km²**). This was based on a length of 70 m, and width of 8 m.

3.3.2.4 To ensure the worst case is assessed the value presented in the ES will be taken forward. To confirm the footprint of cable rock protection at the Greenlink interconnector cable crossing is based on 150m length and 14 m width, resulting in a worst case 150 x 14 m = **2,100 m²** (**0.0021 km²**).

Long Term Habitat Loss at Turbot Bank

3.3.2.5 Following confirmation of the maximum footprint of the external cable rock protection for the Greenlink cable crossing rock protection at Turbot Bank of 2,100 m² (0.0021 km²) (see above), the below section presents a summary of the predicted spatial extent of the long-term habitat loss of the Annex I sandbank Turbot Bank.

3.3.2.6 The 0.0021 km² rock protection at the Greenlink crossing, represents 0.011% of the total area occupied by Turbot Bank within the SAC boundary (19.1 km²). The total area of Turbot Bank (e.g. the total area both inside the SAC and outside of it) is 24.05 km², and therefore, this represents 0.0087% of the entire bank. The proposed 0.0021 km² area of rock protection corresponds with 0.0041% of the 51.59 km² total Annex I Sandbank habitat reported to be present within the boundary of the Pembrokeshire Marine SAC.

3.3.2.7 This re-assessment of the spatial extent of long-term habitat loss during the O&M phase at the Annex I Turbot Bank from the placement of external cable rock protection at the Greenlink cable crossing (both as a proportion of the habitat within the SAC, and in total), does not result in any material change in the original assessment presented in the ES. Therefore, it is confirmed that a **minor adverse** effect is determined, which is not significant in EIA terms.

3.3.3 Potential Changes to the Morphology of Turbot Bank

Existing Assessment(s)

3.3.3.1 In the ES Volume 1 Chapter 6: Marine and Coastal Processes, sediment transport patterns had been modelled, whereby complex patterns were described near and around Turbot Bank. It was determined that the external cable rock protection berms, had little or no potential to disrupt long-term sediment transport locally, or regionally, through changes in waves or current patterns.

3.3.3.2 In the ES Volume 1 Chapter 9: Marine and Coastal Ecology, indirect long-term changes to physical processes were assessed for the O&M Phase (Section 9.6.3, paragraphs 9.6.3.114-9.6.4.2). Specific reference had been made in this section to the Greenlink cable crossing at Turbot Bank (paragraphs 9.6.3.122 – 9.6.3.126).

3.3.3.3 Following the formal consultation response, and discussions with NRW Advisory in a subsequent Expert Topic Group (ETG) meeting with ABPmer (25 May 2022), it had been agreed that the assessments were theoretically reasonable, having been based on available evidence. However, uncertainty remained on the assessment, in relation to a baseline understanding of sandwave migration rates on Turbot Bank, and finer details on sediment transport pathways and linkages to the wider area. It was agreed that the evidence used to inform the original assessment remained valid, and no additional information was available.

3.3.3.4 Following this formal consultation response, consideration thus must also be given on the potential impacts on benthic ecology. That is, if the habitats of Turbot Bank and the communities it supports will be impacted by any potential changes in bank morphology caused by the external cable rock protection at Greenlink crossing, in combination with the cable protection to the north and south of Turbot Bank.

Review of Existing Assessments

3.3.3.5 Following a review by ABPmer of the existing assessments in the ES Volume 1 Chapter 6: Marine and Coastal Processes, it was determined that both the findings and conclusions remain valid and, at this stage, no additional assessments were required.

3.3.3.6 Blue Gem Wind (BGW) has mitigation commitments of undertaking pre- and post-installation bathymetric surveys of the ECC, that will focus on areas of interest, including the Annex I Turbot Bank feature. Details of this monitoring are captured in an Outline Environmental Monitoring Plan (OEMP) that has been prepared at the request of NRW Advisory, and forms part of this submission of supplementary information. Future monitoring of seabed morphology in and around Turbot Bank will provide the additional data to further inform and validate these assessments.

3.3.3.7 In consideration of the review by ABPmer of the existing assessments on marine coastal processes, it is concluded that for the purpose of this supplementary addendum, no additional ecological assessment is required regarding Turbot Bank, to support the existing assessments of the ES Volume 1 Chapter 9: Marine and Coastal Ecology.

3.4 Suspended Sediments and Sensitive Features (Maerl Beds)

3.4.1 Overview

3.4.1.1 The presence and predicted spatial extent of Section 7/OSPAR Maerl (*Lithothamnion coralloides* (coral maërl) and *Phymatolithon calcaereum* (common maërl)) in the Milford Haven Waterway is presented in Volume 1 Chapter 9: Marine and Coastal Ecology of the ES, where a known bed is present on the northern side of the waterway (Volume 2 Figure 9.5). These beds are approximately 1.7 km distant from KP 0.5, at the landfall at West Angle Bay.

3.4.1.2 The location of these Maerl beds was obtained from the Lle Geo-Portal.

3.4.1.3 The potential impacts on Maerl beds via temporary increases in suspended sediment concentrations (SSC) and associated potential smothering via cable installation and landfall works (including the potential release of drilling muds (bentonite) from HDD works) was assessed in ES Volume 1 Chapter 9: Marine and Coastal Ecology, Section 9.6.2 (paragraph 9.6.2.59). This assessment had been informed by the specialised evidence-based approach undertaken as part of ES Chapter 6: Marine and Coastal Processes, which itself was informed by Project-specific baseline data (including particle size analysis (PSA) data). The original assessment predicted no measurable thickness of sediment accumulation on Section 7/OSPAR features.

3.4.1.4 Following the formal consultation response from NRW Advisory, ABPmer has provided supplementary information using numerical modelling to assess the magnitude, duration, and extent of local increases in SSC and deposition in relation to these Maerl beds (see Section 2.2).

3.4.1.5 This section provides a summary of the relevant baseline environment and additional modelling assessments undertaken by ABPmer, and an ecological assessment of the potential impacts on this protected feature.

3.4.2 Relevant Baseline Environment

Marine Processes

3.4.2.1 A full description of the baseline environment across the marine and coastal processes study area is provided in the ES Volume 1 Chapter 6: Marine and Coastal Processes and presents the findings of the Project-specific oceanographic, geophysical and geotechnical surveys undertaken in 2020/21, and other pre-existing data.

3.4.2.2 Tidal current speeds vary in response to tidal cycles, as well as depth. Moving inshore current speeds increase to ~1.0 to 1.4 m/s near the approach to Milford Haven, decreasing within the Haven to 0.4 to 0.6 m/s on a mean spring tide. Due to the large tidal range, the water exchange and movement through Milford Haven Waterway is significant, with an average tidal excursion of 8 to 10 km on a spring tide, and 4 to 5 km on neap tides.

3.4.2.3 SSC varies temporally and spatially, and with water column depth. Project-specific surveys collected water samples in the inshore/nearshore ECC (between the landfall and KP 8) in November 2020, and observed SSC was nearly always <10 mg/l, which is low in absolute and relative terms. Monthly averaged satellite imagery of suspended particulate matter (SPM) suggests a seasonal low during summer months (~ 3 mg/l at the nearshore end of the ECC), and a slight increase during winter. In practice, higher values (potentially several tens or hundreds of mg/l) are realistically predicted in some locations, during larger spring tides and during storm conditions, and with the greatest concentrations encountered near the seabed. The 2020 water samples reported that maximum SSC was observed at the seabed, where it was 20 mg/l in depths <10 m LAT, and 23 mg/l in depths >10 m LAT.

3.4.2.4 Within Milford Haven itself, there is a variety of fine sedimentary inputs contributing to baseline SSC conditions, ranging from urban and industrial developments, to riverine, with a pattern within the Haven of reduced SSC with distance down-estuary. Water sampling undertaken in the main channel of the Haven (approximately opposite West Angle Bay and in the vicinity of the Maerl beds to the north of the channel), recorded total suspended solids (TSS) to range between 5 and 10 mg/l, but with peaks of up to 44 mg/l.

Maerl beds

3.4.2.5 Regionally, there are a few records of *L. corallioides* and *P. calcaereum*, and predominantly from a localised location within Milford Haven. These beds are located to the north of the marine terminals, on the northern side of the Haven, and to the west of Gelliswick Bay. Historic records of Maerl have dated back to the late 1970s, but with infrequent data collected during this time (NBN Atlas, 2022a; 2022b; 2022c; OBIS, 2022).

3.4.2.6 The bed is ancient, with a fossil sample collected from Stack Rock dating back to between 184 BC and 12 AD (review by JNCC, 2019a). A 2005 NRW survey in Milford Haven, mapped the extent, density and ratio of live and dead thalli of Maerl, with the aim to provide a baseline for monitoring the bed in the Haven. Bed area was reported to be approximately 1.5 km^2, of which only 0.5 km^2 contained living Maerl among dead Maerl gravel (review by OSPAR Commission, 2020) (see ES Volume 2 Figure 9.5 for current known extent and location, as provided by Lle Geo-Portal (2022)).

3.4.2.7 A later habitat mapping survey by Cary *et al.* (2015) described this feature as belonging to the sediment facies ‘shell dominated sand’, located within areas subject to high currents, and was assigned the ‘best-fit’ EUNIS biotope of A5.515 (‘Association with rhodolithes in coarse sands and fine gravels under the influence of bottom currents’), belonging to the parent biotope A5.51 (‘Maerl beds’).

3.4.2.8 Diverse communities can be associated with Maerl beds, which can create a unique biogenic habitat (Perry *et al.,* 2018). The small green epiphyte *Cladophora rhodlithicola sp. nov.,* has been described to be associated with the thalli of Maerl, and has been sampled from the beds at Milford Haven, and confirmed with molecular analysis. It has been observed to grow on both live and dead rhodolithes (Leliaert *et al.,* 2009).

3.4.2.9 There has been a reported deterioration of the beds in Milford Haven, which has partly been attributed to the refurbishment works at the South Hook Jetty, and from dredging activity (maintenance dredging). Indicators of this decline include reduction in average percentage of live thalli, and reduction in infaunal diversity. It is unlikely that the remaining habitat is of suitable quality and area to be maintained in the long-term (JNCC, 2019a).

3.4.3 Model Overview

3.4.3.1 A Project-specific numerical model was not required to inform the original assessments presented in ES Volume 1 Chapter 6: Marine and Coastal Processes, as an evidence-based approach was judged to be sufficient. However, post-ES submission, a bespoke hydrodynamic (tide only) and sediment plume model has been developed to inform ongoing engineering and design studies. This model is based upon the calibrated ABPmer SEASTATES Tide and Surge Hindcast model (ABPmer, 2017). The model has been refined and reassessed for the purpose of simulating detailed hydrodynamic processes for the Project Floating Offshore Windfarm, and associated ECC. The hindcast modelling for this study has been undertaken using the MIKE21FM (flexible mesh) software package from the Danish Hydraulic Institute (DHI).

3.4.3.2 The model is a 2-D depth averaged flow model, covering the North West European Continental Shelf. For this assessment, the model grid has been refined further to the following:

- Approximately 1 km spatial resolution across the array area and finer along selected areas of the ECC;
  - Approximately 80 m along the nearshore ECC, in and around Rows Rock Channel, and into West Angle Bay; and
  - Approximately 150 m elsewhere within Milford Haven estuary.

Bathymetry and Hydrodynamic Model Boundaries

3.4.3.3 The model bathymetry was compiled from a range of data sources, with the most important being the Project-specific surveys (2020 and 2021), and UK Hydrographic Office (UKHO) data.

3.4.3.4 The (tide only) hydrodynamic model uses four open tidal water level boundaries; three offshore of the continental shelf, and one at the entrance to the Baltic Sea.

3.4.3.5 The hydrodynamic model was run for a continuous 15 day simulation period, from 20 March to 8 April 2021, providing a range of realistic conditions, including depth averaged flow speed, direction and surface elevation data, at ten-minute intervals

Sediment Plume Modelling Approach

3.4.3.6 The sediment plume modelling is undertaken using a particle tracking approach. Particle tracking is a sub-module of the hydrodynamic model described above, also using the MIKE by DHI software.

3.4.3.7 The plume modelling specifically considered the effect of the finer sediments that are likely to remain in suspension for long enough to contribute to elevated SSC, over timescales, and distances large enough to interact with the Maerl beds. Coarser material (i.e. sands and gravels) will settle to the seabed too rapidly to affect the Maerl beds at all, and so are not included in these plume models.

3.4.3.8 For the plume modelling, representative mean spring and mean neap tidal range conditions were identified around 29 March and 6 April 2021, respectively.

3.4.3.9 The particle tracking model records the horizontal and vertical position of the individual particles over time.

3.4.3.10 The plume scenarios are designed according to the realistic worst case design scenarios (described in the following sections) for:

- Export cable burial close to the landfall; and
- Drilling fluid (bentonite) release during HDD at the landfall.

3.4.3.11 See (Section 2.2) for full details of the model and sediment release scenarios for each realistic worst-case design.

Summary Output

3.4.3.12 **Export Cable Burial:** With reference to proposed cable trenching in West Angle Bay, and at the approaches to Milford Haven along the ECC, the majority of the disturbed sediments will comprise sand and gravels (90%), with only between 5-10% of fines present.

3.4.3.1 Disturbed sediments will result in very high concentrations near the point of active trenching, with rapid rate of re-settlement of sand and gravel fractions. The model excluded these coarser fractions, and specifically only considered, and thus reported, the effect of finer sediments that may be resuspended during cable burial works, that has a greater dispersal distance and may interact with Maerl features. The model was run on a realistic scenario of 5% fines, as a greater proportion is only likely to occur for relatively short time periods and in localised conditions.

3.4.3.2 It was predicted that under maximum spring tide conditions, the re-suspended fine sediments will result in a weak sediment plume, that will spatially overlap with the known location of the Maerl beds.

3.4.3.3 It was predicted that under neap conditions, modelled increases in SSC overlapping the live areas of Maerl beds are negligible, or zero, at any time of the release timing scenarios. Although the excursion distance under neap tidal conditions is sufficient to advect the sediment plume within the near vicinity of the Maerl beds, the associated current speeds and direction confine the plume to the main channel, to the south of the beds.

3.4.3.4 Sediment deposition thickness in and around the area of the live and/or dead Maerl beds is predicted to be <1 mm (<1 g/m^2) in all cases, which is not measurable in practice and will be, at most, comparable to normally occurring patterns as a result of natural processes and other vessel movement related disturbances

3.4.3.5 Table 3-1 below summarises the key modelled outputs predicted for cable trenching along the ECC, under the maximum (worst-case) spring tidal conditions (see Section 2.3 for full modelled outputs of the scenarios).

3.4.3.6 **Drilling Fluid Release:** During HDD works at the shallow subtidal area of the landfall, the release of drilling fluid into the coastal waters at the two HDD exit (punch-out) points may cause a sediment plume in the nearshore area, which may advect towards Milford Haven and the Maerl beds.

3.4.3.7 The drilling fluids will contain a low concentration of bentonite (5%); it is a natural material and is on the PLONOR List[4]. During HDD works, the release of drilling muds is expected to occur over a short duration <1 hour, with a fine sediment release rate of 15.71 kg/s. It is assumed that there will be just two releases during the Construction Period, and that they would not take place concurrently.

3.4.3.8 Under maximum spring tide conditions, the fine sediments re-suspended for drilling fluid release during HDD at the landfall are modelled to cause a weak sediment plume that will spatially overlap with the known location of the Maerl beds.

3.4.3.9 Under neap conditions, modelled increases in SSC are negligible or zero at any time of all of the release timing scenarios. Although the excursion distance under neap tidal conditions is sufficient to advect the sediment plume within the near vicinity of the Maerl beds, the associated current speeds and direction confine the plume to the main channel, to the south of the beds.

3.4.3.10 Sediment deposition thickness in and around the area of the live and/or dead Maerl beds is predicted to be <1 mm (<20 g/m^2) in all cases, which is not measurable in practice and will be, at most, comparable to normally occurring patterns as a result of natural processes and other vessel movement related disturbances

Table 3-1: Summary of Modelled Predicted Increases in SSC and Deposition at Maerl beds under Spring (Maximum) Tide conditions

Scenario Modelled	Output under Spring Tide Conditions
Export Cable Burial	**Maximum Increases in SSC:** • Maximum increase in SSC at live Maerl beds: ~ 30 mg/l. • Duration of maximum increase in SSC at live Maerl beds: only in order of 10 minutes and infrequent. **Typical Increases in SSC:** • Typical increase in SSC in area of Maerl: ~ 10-20 mg/l. • Duration of typical increase in SSC in area of Maerl beds: 1-4 hours and frequent. **Negligible/Zero Increases in SSC:** • Typical increase in SSC in area of Maerl: ~0 mg/l or negligible • Duration of negligible/zero increase in SSC in area of Maerl beds: frequently. **Sediment Deposition Thickness** In and around live/dead Maerl: <1 mm (<1 g/m^2) in all cases (not measurable in practice).

[4] OSPAR List of Substances Used and Discharged Offshore Which are Considered to Pose Little or No Risk to the Environment (PLONOR) (OSPAR Commission, 2021).

Scenario Modelled	Output under Spring Tide Conditions
Drilling Fluid (bentonite) Release during HDD	**Maximum Increases in SSC:** • Maximum increase in SSC at live Maerl beds: ~ 30 mg/l. • Duration of maximum increase in SSC at live Maerl beds: only in order of 10 minutes and infrequent. **Typical Increases in SSC:** • Typical increase in SSC in area of Maerl: <10 mg/l. • Duration of typical increase in SSC in area of Maerl beds: 1-4 hours and frequent. **Negligible/Zero Increases in SSC:** • Typical increase in SSC in area of Maerl: ~0 mg/l or negligible • Duration of negligible/zero increase in SSC in area of Maerl beds: frequently. **Sediment Deposition Thickness** In and around live/dead Maerl: <1 mm (<20 g/m^2) in all cases (not measurable in practice).

3.4.4 Ecological Assessment

3.4.4.1 The updated assessments of expected increases in SSC and associated deposition on Maerl, has validated the original assessments in ES Volume 1 Chapter 6: Marine and Coastal Processes.

3.4.4.2 It is predicted that, for the cable laying works starting at West Angle Bay, the moving release of sediments will continue for 12 hours whereby, at KP 6, it is determined to be sufficiently far offshore of Milford Haven that from this point on, any locally generally suspended sediment plume will be dispersed into the offshore, and not into the Haven.

3.4.4.3 As described above, the majority of sediments released will constitute heavier, coarser particles, with only 5-10% (typically, 5%) being finer sediments. For the HDD works at the landfall, drilling activity will only require two sperate release events during the Construction Phase, which are not expected to occur concurrently.

3.4.4.4 The maximum predicted SSC of 30 mg/l in the plume generated by the cable lay works at the ECC, and from HDD at the landfall, are both extremely limited in duration (minutes) and infrequent in the area of Maerl. It is predicted that concentrations will frequently be either negligible or zero, or reach between 10 and 20 mg/l; which is within range of baseline conditions within this reach of the Haven.

3.4.4.5 The deposition associated with increased SSC arising from each of the activities, on living and/or dead Maerl is predicted to be <1 mm in thickness and, if combined, this will remain as negligible thickness, and not measurable in practice.

3.4.4.6 In consideration of the limited duration of both activities during the construction phase, and the expected small increase in SSC and associated deposition that may occur in the area of the Maerl beds, the magnitude of this potential impact is assessed to be **Negligible.**

3.4.4.7 The species *L. coralloides* and *P. calcaereum* are both Section 7 priority species, afforded protection under Section 7 of the Environment (Wales) Act 2016, as is its corresponding habitat, Maerl beds, as a priority habitat. Maerl beds are also listed under the OSPAR List of Threatened and/or Declining Species and Habitats in the North-East Atlantic, and are, therefore, of Medium value.

3.4.4.8 Maerl is very vulnerable to increased levels of suspended sediments, in particular fine organic sediments that may be anthropogenically generated from dredging activities, and fisheries, and from the faeces and pseudo faeces of the slipper limpet *Crepidula fornicata* (review by JNCC 2019a). Following the Marine Evidence–based Sensitivity Assessment (MarESA) by Perry *et al.* (2018), for the parent biotope A5.51 (Maerl beds), the following physical pressure pathways, relevant to the activities, were reviewed:

- **Changes in suspended solids (water clarity)**: whether the sediment plume(s) generated by the activities impact the light attenuation of the water column, upon which the thalli growth is dependant; and
- **Smothering and siltation rate changes (‘light’ and ‘heavy’)**: whether associated deposition from the sediment plume(s) exceeds the 5 cm benchmark, where it is likely to clog or reduce water flow at the beds.

3.4.4.9 The parent biotope ‘Maerl beds’ (A5.51) has been assessed as having medium resistance and very low resilience to reductions in water clarity, and overall is reported to have medium sensitivity to this pressure.

3.4.4.10 For both ‘light’ and ‘heavy’ smothering and siltation rates, the biotope has no resistance to this pressure, with very low resilience, and overall high sensitivity. Maerl exhibits a variation in responses to deposition, depending on sediment type, whereby it is most sensitive to finer sediment fractions. The predicted deposition of fines from the cable lay and HDD activities at the nearshore part of the ECC and landfall will not meet the minimum 5 cm benchmark of ‘light’ smothering and, thus, does not meet the benchmark for ‘heavy’ smothering. Furthermore, any settled sediments may become re-suspended by waves and tides. It is also important to be cognisant of the fact that settled sediments will not simply sit on the top of the bed, where they may be re-suspended, but will penetrate the open matrix of the bed.

3.4.4.11 Although the magnitude of impact from the activities is unlikely to exceed the sensitivity benchmark for water clarity and smothering and siltation on this feature, adopting a precautionary approach, a **High** sensitivity is assigned to the Maerl beds in Milford Haven.

3.4.4.12 In summary, the updated assessment of increased SSC and associated deposition via sediment plumes generated via cable installation and HDD works at landfall, which have been informed by additional modelling outputs from ABPmer, concludes that the negligible magnitude of impact combined with the high sensitivity of the receptor will result in a **minor adverse** effect on Maerl beds, which is not significant in EIA terms.

3.5 Potential Impacts on Annex I Habitat Features via Landfall Works at West Angle Bay

3.5.1 Overview

3.5.1.1 The landfall cable preferred route option is through the middle of West Angle Bay. To maintain the necessary flexibility to the Project there are two options for cable lay and installation at the landfall:

- **Preferred Option**: Horizontal directional drilling (HDD); and
- **Contingency Option**: Open-cut trenching.

3.5.1.2 The proposed preferred method of cable laying at the landfall (HDD), will require two exit points with associated external rock protection in the shallow subtidal area. If HDD is found to not be a feasible option, then open-cut trenching is the proposed contingency option at the landfall, and this represents the worst-case scenario. Each option is described in full in ES Volume 1 Chapter 4: Proposed Development Description, and summarised in this section.

3.5.1.3 For the assessment in the ES Volume 1 Chapter 9: Marine and Coastal Ecology to be fully comprehensive, the worst-case scenario of open cut trenching was assessed, which will result in the permanent loss and temporary disturbance of habitats. It is recognised that the preferred HDD option, which requires external cable protection at the exit points, will also result in long-term habitat loss, as well as the release of drilling muds and suspended sediments during construction (see preceding section for details on SSC impacts).

3.5.1.4 To provide clarity, the assessments included in ES Volume 1 Chapter 9: Marine and Coastal Ecology, are re-presented here, not by impact (e.g. temporary direct disturbance vs. habitat loss), but separately by the two different cable lay options. This will allow a clearer understanding of the effects associated with each option for cable lay at the landfall, specifically the magnitude of impact on the following relevant protected Annex I benthic features:

- Annex I rocky reef;
- Annex I sea caves; and
- Annex I intertidal mudflats and sandflats.

3.5.1.5 Any indirect habitat disturbance on Annex I features at the landfall and surrounding far-field areas, caused by the impact pathway of increases in SSC and associated siltation/smothering from the suspended sediment plumes and drilling muds (bentonite) from the proposed works, is not presented here. A full assessment of this is presented in the ES Volume 1 Chapter 9: Marine and Coastal Ecology (paragraphs 9.6.2.46-9.6.2.93) and further assessed, above, in Section 3.4, with specific reference to Section 7/OSPAR protected Maerl beds in the Milford Haven Waterway.

3.5.2 Preferred Option: Horizontal Directional Drill

Summary of Works

3.5.2.1 The HDD option is the preferred option, as a trenchless option it reduces the overall footprint on the shallow subtidal and intertidal benthic habitats at West Angle Bay. It creates an underground conduit between the shallow subtidal (3-5 m lowest astronomical tide (LAT)) and the onshore parts of the export cable route.

3.5.2.2 There are two cable route options for the HDD at the landfall, the 'northern' route through the middle of West Angle Bay (the preferred option), and the 'southern' route which approaches the bay to the south (see ES Volume 2 Figure 4.13b for the location of both). The preferred 'northern' route, is assessed here, where the HDD works will be located between KP 0.5 and KP 1, in the shallow subtidal landfall area (see ES Volume 2 Figure 9.13a).

3.5.2.3 The HDD option will require two exit ('punch-out') points in the shallow sub-tidal region, with external rock protection required at the two exit points. The HDD cable installation works are expected to last up to 32 weeks, during the Construction Phase of the Project.

3.5.2.4 A Cable Lay Vessel (CLV) with a shallow draft flat keel will be deployed to install the export cable, approximately 700 m from Mean High Water Springs (MHWS), near the HDD exit point. A CLV can be self-propelled or rely on support vessels. In addition to a CLV, two Anchor Handling Tug (AHT) vessels, a guard vessel, and up to two rigid inflatable boats (RIBs) will be required during the installation works. The location of the HDD exit points along the ECC, and any nearby vessel activity and associated anchoring, are likely to occur within the extensive sedimentary area of the landfall at West Angle Bay (see ES Volume 2 Figure 9.13a).

3.5.2.5 The availability of vessels may require the use of Nearshore Floatation Pits (NFPs), for vessels of greater draft that cannot access the shallow sub-tidal region at West Angle Bay during cable installation. NFPs are typically 160 m (length) x 45 m (width) (and with a depth of 5 m), a total footprint of 7,200 m^2. The combined predicted activities of vessels, and NFPs, can result in temporary habitat disturbance of the shallow sedimentary habitats of West Angle Bay. NFPs were included in the original assessment presented in ES Volume 1 Chapter 9: Marine and Coastal Ecology.

3.5.2.6 The drill will have a diameter of up to 1.2 m, and during drilling at the two HDD exit points, there will be the production and release of drilling fluids (or drilling mud) from the two boreholes, that will be comprised of water and bentonite clay.

3.5.2.7 External rock protection (4 tonnes rock bags, 25 mm mesh size) is required at the two HDD exit points, each with a maximum footprint of 105 m^2, covering a total area of 210 m^2.

3.5.2.8 Through the option of HDD, temporary direct habitat disturbances during the Construction Phase will arise from the footprint of vessels operating, and the temporary NFPs that may be required.

3.5.2.9 Through the option of HDD, there will be long-term habitat loss during the O&M Phase, where the two HDD exit point bore holes are protected by rock berms. These are to be removed at the end of the O&M Phase.

3.5.2.10 Table 3-2 summarises the key Project parameters in relation to the HDD option and direct impact pathways on benthic ecology, with maximum (worst-case) parameters described.

Table 3-2: Summary of area (m^2) of direct impacts associated with HDD

Project Phase/Impact	Realistic Worst Case Scenario	Description
Construction		
Temporary Habitat Disturbance	• Footprint of vessels (placement of anchor vessel deployments): 1,000 m^2 • Area of temporary flotation pit: 7,200 m^2 • Volume of drilling mud: 2,400 m^3 • Duration: 32 weeks Total area footprint (m^2/km^2) of temporary habitat disturbance from HDD works at the landfall: **8,200 m^2 (0.0082 km^2)**	Vessel deployments: This represents the maximum footprint from vessel activity at the landfall during the proposed works. Floatation pit: This represents the maximum area of 7,200 m^2, which is based on maximum dimensions of 160m length x 45 m width (and with a depth of 5 m). Drilling mud volumes: This represents the maximum volume of drilling muds to be released during HDD. Duration: This represents the maximum number of weeks over which habitat disturbance will occur , for either the 'northern' or 'southern' HDD route option at the landfall. **Total area of temporary habitat disturbance:** This represents the total direct disturbance footprint from vessels and the temporary flotation pits during the construction phase.
Operation and Maintenance		
Long-term habitat loss	• HDD exit protection areas: 210 m^2 • Duration: <25 years Total area (m^2/km^2) of long-term habitat loss at the landfall: **210m^2 (0.00021 km^2)**	HDD exit protection area This represents the dimensions of the two areas of rock berm protection at the two HDD exit points, each with maximum dimensions of 21 m length x 5 m width (and 1.2 m height) (105 m^2). Duration This represents the maximum O&M period for the Project, and how long the rock protection will be in place at the landfall. **Total area of long-term habitat loss:** This represents the total area of the two rock berms at the HDD exit points, each of which is 105 m^2, and will be installed for the lifetime of the Project (< 25 years).

Annex I Rocky Reef – Temporary Direct Habitat Disturbance during Construction

3.5.2.11 There is no temporary direct habitat disturbance predicted for Annex I rock reef at West Angle Bay via the HDD option at landfall.

3.5.2.12 The indirect habitat disturbance to Annex I rocky reef from the impact pathways of increased SSC and smothering from suspended sediment plumes generated during the Construction Phase has been assessed separately in the ES Volume 1 Chapter 9: Marine and Coastal Ecology (paragraph 9.6.2.63 – 9.6.2.69).

Annex I Rocky Reef – Long-term Habitat Loss during O&M

3.5.2.13 There is no long-term habitat loss predicted for Annex I rock reef at West Angle Bay via the HDD option at landfall.

Annex I Rocky Reef – Permanent Habitat Loss during O&M

3.5.2.14 There is no permanent habitat loss predicted for Annex I rocky reef at West Angle Bay via the HDD option at landfall.

Annex I Sea Cave - Temporary Direct Habitat Disturbance during Construction

3.5.2.15 No temporary direct habitat disturbance is predicted for Annex I sea caves via the HDD option at landfall. See ES Volume 2 Figure 9.9 for the location of the sea caves at West Angle. These are too distant from the ECC to be exposed to direct habitat disturbances from the works.

3.5.2.16 The indirect habitat disturbance on Annex I sea caves for the Pembrokeshire Marine SAC, from the impact pathways of increased SSC and smothering from suspended sediment plumes generated during the Construction Phase, has been assessed as part of intertidal and infralittoral Annex I rocky reef in the ES Volume 1 Chapter 9: Marine and Coastal Ecology (paragraph 9.6.2.63 – 6.6.2.69).

3.5.2.17 The indirect habitat disturbance on Annex I sea caves for the Limestone Coast of South West Wales SAC, from the impact pathways of increased SSC and smothering from suspended sediment plumes generated during the Construction Phase has been assessed separately, here - see Section 3.6.

Annex I Sea Cave - Long-term Habitat Loss during O&M

3.5.2.18 No long-term habitat loss is predicted for Annex I sea caves from the HDD option at landfall. There is no impact pathway for long-term habitat loss on this feature, with no Project associated infrastructure proposed to be overlapping this feature.

Annex I Sea Cave - Permanent Habitat Loss

3.5.2.19 No permanent habitat loss is predicted for Annex I sea caves from the HDD option at landfall. See ES Volume 2 Figure 9.9 for location of the single sea cave at West Angle Bay. It is too distant from the ECC to be exposed to permanent habitat loss from the proposed works.

Annex I Intertidal Mudflats and Sandflats – Temporary Direct Habitat Disturbance during Construction

3.5.2.20 There is no temporary direct habitat disturbance predicted for Annex I intertidal mudflats and sandflats at West Angle Bay via the HDD option at landfall.

3.5.2.21 The indirect habitat disturbance on Annex I intertidal mudflats and sandflats from the impact pathways of increased SSC and smothering from suspended sediment plumes generated during the Construction Phase has been assessed separately in ES Volume 1 Chapter 9: Marine and Coastal Ecology (paragraph 9.6.2.79 – 9.6.2.82).

Annex I Intertidal Mudflats and Sandflats – Long-term Habitat Loss during O&M

3.5.2.22 There is no long-term habitat loss predicted for Annex I intertidal mudflats and sandflats at West Angle Bay via the HDD option at landfall.

Annex I Intertidal Mudflats and Sandflats – Permanent Habitat Loss

3.5.2.23 There is no permanent habitat loss predicted for Annex I intertidal mudflats and sandflats at West Angle Bay via the HDD option at landfall.

3.5.3 Contingency Option: Open-Cut Trenching

Summary of Works

3.5.3.1 Although HDD is preferred, without detailed feasibility and geotechnical surveys (to be undertaken post-consent), the risk remains that HDD is not technically feasible and, therefore, open-cut trenching, comprising a single trench, is considered as a contingency option. The trench would likely be partitioned into two sections, the nearshore intertidal section which would be excavated by land-based equipment, and the subtidal section which would require excavation by marine plant/vessels.

3.5.3.2 For the nearshore, a conventional track-based excavator would be used to open up the trench, where excavation and installation would likely occur at low tide.

3.5.3.3 Material would be removed from the shallow subtidal either using a shallow draft barge with backhoe excavator, or a “walking spider” excavator. A CLV with a shallow draft flat keel would be required during the work to install the export cable near the shore. The CLV would likely to be anchored approximately 700 m from MHWS, and would be assisted by RIBs to assist with cable alignment. At this distance, the anchoring of the CLV would be likely to overlap with sediments of the shallow sublittoral, and not hard substratum. In addition, two AHT vessels, and a guard vessel would be required during the works. The maximum footprint from vessel activity is predicted to be 1,000 m^2. On the shoreside of the landfall, plant machinery would be in operation during the trenching works

3.5.3.4 The availability of vessels may require the use of NFPs for vessels of greater draft, that cannot force to ground at West Angle Bay during cable installation. NFPs would be typically 160 m (length) x 45 m (width) (and with a depth of 5 m), a total footprint of 7,200 m^2. The combined predicted activities of vessels, and NFPs, can result in temporary habitat disturbance of the shallow sedimentary habitats of West Angle Bay.

3.5.3.5 For the open-cut trenching activity itself, the total footprint of works at the landfall ECC is 6,500 m^2. This represents a maximum corridor width of 10 m, over a length of 650 m across the intertidal and shallow subtidal area that will be affected. A 3 m width, of the overall 10 m width, would be subject to the direct physical disturbance of substratum extraction, i.e. the cable trench itself. The remaining 7 m (3.5 m either side of the 3 m wide trench) would be impacted by the temporary storage of side-cast materials during sediment removal and backfilling, and vehicle access on the shoreside of the trench at the landfall.

3.5.3.6 Across this 6,500 m^2 ECC footprint, 6,354 m^2 will be subject to temporary direct habitat disturbance. Much of this will comprise shallow subtidal and intertidal sedimentary habitat and, therefore, will only be vulnerable to temporary habitat disturbances associated directly from the trenching and the backfilling activities of sediments within the 3m trench; or habitat disturbances 3.5 m either side (the temporary storage of sediment *in situ* along the trench, and plant access). The temporary use of coffer dams may also be required during trenching, to keep the shape and structure of the 3 m trench in place during the works, after which the coffer dams would be removed, the trench backfilled, and the beach returned to baseline conditions.

3.5.3.7 Of this 6,354 m^2 footprint, it is predicted that only 276 m^2 (0.00028 km^2) will overlap intertidal hard substratum, and thus intertidal Annex I rocky reef, and that only 498 m (0.0005 km^2) will overlap shallow water subtidal Annex I rock reef. This equates to a total of 776 m^2 (0.00078 km^2) of Annex I reef that may be impacted by temporary direct habitat disturbance from the ECC and associated works at the landfall.

3.5.3.8 The remaining 146 m^2 of this 6,500 m^2 footprint comprises rocky habitat, which is predicted to directly overlap the 3 m wide trench, and would need to be excavated, removed, and could not be backfilled as can be done for sediments. This, therefore, would represent permanent habitat loss for the option of open-cut trenching. Rock cutting tools remain an option for trenching of both loose and hard substrates.

3.5.3.9 Table 3-3 summarises the key Project parameters in relation to the open-cut trenching option and direct impact pathways on benthic ecology, with maximum (worst-case) parameters described. ES Volume 2 Figure 9.13e provides a graphical representation of the open-cut trenching option across the landfall at West Angle Bay.

Table 3-3: Summary of area (m^2) of direct impacts associated with open-cut trenching option at the landfall

Project Phase/Impact	Realistic Worst Case Scenario	
Construction		
Temporary Habitat Disturbance	• Footprint of vessels (placement of shallow barge deployment and vessel anchors): 1,000 m^2 • Area of flotation pit: 7,200 m^2 • Area of disturbance association with associated with trenching: 6,354 m^2 • Duration: 15 weeks	Vessel deployments: This represents the maximum footprint from vessel activity at the landfall during the proposed works. Floatation pit: This represents the maximum area of 7,200 m^2, which is based on maximum dimensions of 160 m (length) x 45 m (width) (and with a depth of 5 m).

Project Phase/Impact	**Realistic Worst Case Scenario**	
	Total area of temporary habitat disturbance from open-cut trenching at landfall: **14,554 m^2 (0.014 km^2)**	Area of works: This represents the area of temporary habitat disturbance from open-cut trenching (not including any vessel disturbances from anchoring). Habitat disturbances associated with trenching works would be 650 m length and 7 m width. Duration This represents the maximum number of weeks for open-cut trenching at the landfall. **Total Area of temporary habitat disturbance:** This represents the total area of benthic habitat disturbed during the open-cut trenching activities (vessel footprint(s); flotation pit, and disturbances associated with trenching.
Operation and Maintenance		
Permanent habitat loss	Total area of permanent habitat loss from open cut trenching interacting with rocky habitat: **146 m^2 (0.000146 km^2)**	Area of Works This represents the area of temporary habitat disturbance from open-cut trenching (3 m wide by 650 m long trench = 1,950 m^2

Annex I Rocky Reef - Temporary Direct Habitat Disturbance during Construction

3.5.3.10 The Valued Ecological Receptor (VER) Groups B, C, D, E and F represent the extensive areas of littoral and infralittoral rock of the intertidal and subtidal zone of the landfall within the Study Area (see ES Volume 2 Figure 9.7b for orthomosaic imagery of West Angle Bay). The dominant VERs were reported to be VER B and VER C, which represent high and moderate exposed bedrock, and boulders. These receptor groups are all deemed to represent Annex I rocky reef, and include the following conservation features:

- Annex I sea cave (a single intertidal cave recorded at the southern end of the West Angle Bay); and
- Section 7/OSPAR intertidal under-boulder communities.

3.5.3.11 The total extent of intertidal Annex I rocky reef at West Angle Bay, as mapped during the intertidal baseline surveys, is 84,000m^2 (0.0085 km^2). Across the shallow subtidal area of West Angle Bay, Annex I rocky reef was also surveyed, where it was reported that it forms an extension of the intertidal rocky reef feature into the infralittoral zone.

3.5.3.12 Potential route options, and micro-siting, of the offshore ECC and vessels across the landfall will avoid, as far as possible, areas of this rocky substratum, but it is predicted that there will be interaction of temporary direct habitat disturbance during open-cut trenching, between the ECC and Annex I rocky reef. It is predicted, however, that the ECC will only interact with:

- 276 m^2 (0.00028 km^2) of intertidal Annex I rocky reef; and
- 498 m^2 (0.0005 km^2) of shallow subtidal Annex I rocky reef.

3.5.3.13 This interaction will result in a total of 778 m^2 (0.000778 km^2) of Annex I rocky reef at West Angle Bay that will be temporarily directly disturbed during the Construction Phase (see ES Volume 2 Figure 9.13e for spatial interaction with the landfall ECC and Annex I rocky reef at West Angle Bay).

3.5.3.14 Within the Pembrokeshire Marine SAC, the extent of intertidal Annex I rocky reef is 11.53 km^2, and the potential intertidal overlap of 0.00028 km^2 at West Angle Bay, represents only 0.0024% of all intertidal Annex I rocky reef in the SAC.

3.5.3.15 Within the Pembrokeshire Marine SAC, the extent of subtidal Annex I rocky reef is 433.15 km^2, and the potential infralittoral overlap of 0.0005 km^2, represents only 0.0001% of all subtidal Annex I rocky reef in the SAC.

3.5.3.16 Within the Pembrokeshire Marine SAC, the total extent of all Annex I rocky reef is 444.68 km^2, and the combined spatial overlap of 0.000778 km^2 from the 650 m long ECC, represents only 0.0002% of all Annex I rocky reef in the SAC.

3.5.3.17 The magnitude of impact of temporary, short-term direct habitat disturbances of open-cut trenching on Annex I reef, as determined by the ES (see Volume 1 Chapter 9: Marine and Coastal Ecology paragraph 9.6.2.13) remains valid as **low**.

3.5.3.18 As there is no change to the assessment of magnitude from the existing ES assessment, that incorporated open-cut trenching activities as part of the worst-case scenario for direct temporary habitat disturbance of Annex I rocky reef, no further assessment is required here. The determination of **minor adverse** for the impact remains valid.

3.5.3.19 The indirect habitat disturbance on Annex I rocky reef from the impact pathways of increased SSC and smothering from suspended sediment plumes generated during the Construction Phase has been assessed separately in the ES Volume 1 Chapter 9: Marine and Coastal Ecology (paragraph 9.6.2.63 – 9.6.2.69).

Annex I Rocky Reef - Long-term Habitat Loss during O&M

3.5.3.20 No long-term habitat loss is predicted for Annex I rocky reef features (refer below for a summary of permanent habitat loss).

Annex I Rocky Reef - Permanent Habitat Loss

3.5.3.21 Open-cut trenching can result in the permanent loss of Annex I rocky reef at the landfall, if the 3 m wide cable trench directly overlaps this feature. It has been predicted that 146 m^2 (0.000146 km^2) of infralittoral Annex I rocky reef (VER Group C) will interact with the 3 m open cut trench, resulting in habitat loss (see ES Volume 2 Figure 9.13e for the spatial interaction with the trench and Annex I rocky reef at West Angle Bay).

3.5.3.22 Within the Pembrokeshire Marine SAC, the extent of subtidal Annex I rocky reef is 433.15 km^2, and this potential infralittoral overlap, and subsequent loss of 0.000146 km^2, represents only 0.00003% of all subtidal Annex I rocky reef in the SAC.

3.5.3.23 Within the Pembrokeshire Marine SAC, the total extent of all Annex I rocky reef is 444.68 km^2, and therefore, the potential infralittoral overlap, and subsequent loss of 0.000146 km^2, represents only 0.00003% of all subtidal Annex I rocky reef in the SAC.

3.5.3.24 The magnitude of impact of the permanent habitat loss of Annex I rock reef from of open-cut trenching, as determined by the ES (see Chapter 9: Marine and Coastal Ecology paragraph 9.6.3.9 - 9.6.3.11) remains valid as **negligible**.

3.5.3.25 As there is no change to the assessment of magnitude, from the existing ES assessment that incorporated open-cut trenching activities as part of the worst-case scenario for permanent habitat of Annex I rocky reef, no further assessment is required here. The determination of **minor adverse** for the impact remains valid.

Annex I Sea Cave - Temporary Direct Habitat Disturbance during Construction

3.5.3.26 No temporary direct habitat disturbance is predicted for Annex I sea caves from the cable lay option of open cut trenching at the landfall (see ES Volume 2 Figure 9.9 for the location of the sea cave at West Angle Bay). It is too distant from the ECC to be exposed to direct habitat disturbances from the cable lay option of open-cut trenching at the landfall.

3.5.3.27 The indirect habitat disturbance on Annex I sea caves of the Pembrokeshire Marine SAC from the impact pathways of increased SSC and smothering from suspended sediment plumes generated during the Construction Phase has been assessed as part of Annex I intertidal and infralittoral rocky reef in the ES Chapter 9: Marine and Coastal Ecology (paragraph 9.6.2.63 – 9.6.2.69)

3.5.3.28 The indirect habitat disturbance on Annex I sea caves for the Limestone Coast of South West Wales SAC from the impact pathways of increased SSC and smothering from suspended sediment plumes generated during the Construction Phase has been assessed separately in this SEI report, in Section 3.6.

Annex I Sea Cave - Long-term Habitat Loss during O&M

3.5.3.29 No long-term habitat loss is predicted for Annex I sea caves from the cable lay option of open cut trenching at the landfall. There is no impact pathway for long-term habitat loss on this feature with no proposed Project associated infrastructure overlapping this feature.

Annex I Sea Cave - Permanent Habitat Loss

3.5.3.30 No permanent habitat loss is predicted for Annex I sea caves from the cable lay option of open-cut trenching at the landfall (see ES Volume 2 Figure 9.9 for location of the single sea cave at West Angle). It is too distant from the ECC to be exposed to permanent habitat loss from the cable lay option of open-cut trenching.

Annex I Intertidal Mudflats and Sandflats - Temporary Direct Habitat Disturbance during Construction

3.5.3.31 Large areas of fine sands and muddy sands (represented by the VER Group K) are deemed to represent Annex I intertidal mudflats and sandflats (see ES Volume 2 Figure 9.7b for orthomosaic imagery of West Angle Bay).

3.5.3.32 The total extent of Annex I intertidal mudflats and sandflats at the landfall of West Angle Bay, as mapped during the intertidal baseline surveys, is 0.058 km^2.

3.5.3.33 It is predicted that the open-trenching works at the landfall will interact with 3,333 m^2 (0.00333 km^2) of Annex I intertidal mudflats and sandflats, and will be subject to short-term temporary disturbances associated with the activities during the Construction Phase.

3.5.3.34 Within the Pembrokeshire Marine SAC, the total extent of Annex I intertidal mudflats and sandflats is 19 km^2, and the potential interaction of 0.003 km^2 represents 0.02% of the total extent of this feature within the SAC. As such, the magnitude of impacts arising from the temporary, short-term habitat disturbances of open-cut trenching on Annex I mudflats and sandflats, as determined by the ES (see ES Chapter 9: Marine and Coastal Ecology paragraph 9.6.2.26) remains valid as **low**.

3.5.3.35 As there is no change to the assessment of magnitude, from the existing ES assessment that incorporated open-cut trenching activities as part of the worst-case scenario for temporary habitat disturbance habitat loss of Annex I intertidal mudflats and sandflats, no further assessment is required here. The determination of **minor adverse** for the impact remains valid.

3.5.3.36 Indirect habitat disturbance on Annex I intertidal mudflats and sandflats from the impact pathways of increased SSC and smothering from suspended sediment plumes generated during the Construction Phase has been assessed separately in the ES Chapter 9: Marine and Coastal Ecology (paragraph 9.6.2.79 – 9.6.2.82),

Annex I Intertidal Mudflats and Sandflats – Long-term Habitat Loss during O&M

3.5.3.37 There is no long-term habitat loss predicted for Annex I intertidal mudflats and sandflats at West Angle Bay, through the cable lay option of open-cut trenching at West Angle Bay.

Annex I Intertidal Mudflats and Sandflats - Permanent Habitat Loss

3.5.3.38 There is no permanent habitat loss predicted for Annex I intertidal mudflats and sandflats at West Angle Bay through the cable lay option of open-cut trenching at the landfall.

3.6 Arfordir Calchfaen de Orllewin Cymru/Limestone Coast of South West Wales Special Area of Conservation

3.6.1.1 The Arfordir Calchfaen de Orllewin Cymru/Limestone Coast of South West Wales SAC is located at Castlemartin, approximately 4 km to the south of the ECC and the landfall at West Angle Bay. It stretches eastwards to the southeast coast of the Gower. Submerged or partially submerged sea caves (H8330) (hereafter referred to as sea caves), are a qualifying but not a primary reason for site selection, and are predicted to cover 0.79 km^2 along the coastline where they are considered to be present (JNCC, 2022a; JNCC, 2015b; NRW, 2018).

3.6.1.2 The sea caves of the Limestone Coast of South West Wales SAC are a functionally linked habitat to sea caves of the Pembrokeshire Marine SAC. Within the Habitats Regulations assessment (HRA) Screening Report (see ES Volume 3 Appendix 8.2), adverse effects on sea caves of the Limestone Coast of South West Wales SAC was assessed as being unlikely, due to low sensitivity of these features to indirect impacts from the Project; however, due to similarity in cross-boundary features with the Pembrokeshire Marine SAC, it was screened in for Stage 2 assessment under HRA.

3.6.1.3 Sea caves of the Pembrokeshire Marine SAC have been assessed in the ES. In response to the formal consultation response, the sea caves of the Limestone Coast of South West Wales SAC will also be assessed, to consider any potential impacts of the Project (see ES Volume 2 Figure 9.4a for extent of the Near-Field and Far-Field Study Area, and Annex I sea cave features).

3.6.1.4 As a protected designated feature, the sea caves of the SAC are assigned a high value. However, the indicative condition assessment of sea caves within the SAC is determined to be unknown, overall. Supported by historic monitoring surveys undertaken in 2002, and expert judgement, the distribution and extent of this feature is assessed to be in favourable condition. However, in relation to structure and function and typical species, its condition is unknown (NRW, 2018).

3.6.1.5 Due to the distance from the landfall, there is no impact pathway for direct temporary habitat disturbance, during the Construction Phase, from either cable lay installation option at West Angle Bay (HDD or open-cut trenching) on the sea caves of the Limestone Coast of South West Wales SAC. Furthermore, there is no predicted long-term or permanent habitat loss from the Project activities on this feature, as the SAC does not overlap the ECC in the Near-Field Study Area.

3.6.1.6 There is, however, a spatial overlap between this Annex I habitat feature and the Far Field Study Area (see ES Volume 2 Figure 9.4a). These features may be vulnerable during all phases of the Project to indirect impacts arising from the suspended sediment plume during disturbance of the seabed from: cable installation, re-burial or remediation, and decommissioning activities, that may result in sediment deposition.

3.6.1.7 As informed by the ES Volume 1 Chapter 6: Marine and Coastal Processes, and summarised in ES Volume 1 Chapter 9: Marine and Coastal Ecology, the maximum plume extent at the nearshore, and thus potentially interacting with the coastline and sea caves of the Limestone Coast of South West Wales is predicted to extend 18-19 km. Within 50 m of the Project activity, suspended sediment concentrations (SSC) will be in the order of thousands to hundreds of thousands of mg/l, however, these reduce rapidly with time and distance to the order of hundreds, or tens of mg/l.

3.6.1.8 Coarser sediments (gravels and coarse sands) are expected to settle in the order of a few minutes to 1.5 hours, potentially resulting in measurable thickness. However, this will be spatially restricted to ~100–500 m distances and, thus, unlikely to interact with sea cave habitats.

3.6.1.9 Finer sediments released at the surface are expected to become widely dispersed (order of several km), and, thus, there is the potential interaction with sea caves along the western region of the Limestone Coast of South West Wales SAC. The wide dispersion of these finer sediments is unlikely to result in measurable thickness across sea caves, as SSC in the water column will rapidly reduce to background levels within a few km of the point of release. The dispersion of sediments resuspended, as a result of disturbance occurring closer to the seabed (e.g. via cable installation and burial), will be significantly reduced compared with releases at the surface.

3.6.1.10 In consideration of the above, the magnitude of impact from the suspended sediment plume and associated deposition, is assessed as **negligible**.

3.6.1.11 Sea caves often support encrusting biota, and may provide habitat for shade-tolerant algae. Within the intertidal zone, sea caves are often subject to strong hydrodynamic regimes and have floors of coarse sediment, cobbles and boulders. The single sea cave identified as present at the landfall at West Angle Bay, and thus the only one surveyed as part of the baseline surveys, was assigned the biotope A1.44C 'Pontic mediolittoral caves with *Hildebrandia*, *Phymatolithon*, Lithophyllum, bryozoans, *Pachygrapsus*, *Eriphia'*, which belongs to its parent classification of A1.44 'Communities of littoral caves and overhangs'. This feature was observed as having a shingle bottom, with encrusting barnacles present.

3.6.1.12 For the purpose of the assessment of sea caves present within the Limestone Coast of South West Wales SAC, the sensitivity of the biotope A1.44 will be reviewed (Hiscock, 2002). Furthermore, to consider submerged (subtidal) sea cave features that may be present along the coast, the sensitivity of the biotope A3.713 (Crustose sponges and colonial ascidians with *Dendrodoa grossularia* or barnacles on wave-surged infralittoral rock) will also be reviewed (Readman, 2016). A3.713 belongs to the parent biotope A3.71 Robust faunal cushions and crusts in surge gullies and caves.

3.6.1.13 The sensitivity of infralittoral cave biotopes (A3.713) to changes in water clarity (increases in suspended sediments) and light smothering and siltation is assessed by Readman (2016) as low. The biotope predominantly occurs along vertical walls, and, although exposed to changes in water clarity, it is unlikely to be exposed to the effects of smothering. Littoral caves (A1.44) are also assessed to show low sensitivity to increases in suspended sediments (Hiscock, 2002). Overall, the sensitivity of sea caves from suspended sediment effects associated with the Project is assessed as **low**.

3.6.1.14 In summary, in terms of increased SSC and associated deposition, the negligible magnitude of impact combined with the low sensitivity of the receptor, results in a **minor adverse** effect on sea caves of the Limestone Coast of South West Wales SAC, which is not significant in EIA terms.

3.6.1.15 This supports the RIAA (see Section 6.6 of ES Volume 3 Appendix 8.3) that concluded there is no potential for an adverse effect on the integrity of the Annex I habitat features of the Limestone Coast of South West Wales SAC from any pressures associated with any effect associated with the Project (alone or in-combination).

3.7 *Sabellaria spinulosa* Reef Assessment

3.7.1.1 The regional account of the Ross worm *Sabellaria spinulosa* is presented in the ES Volume 1 Chapter 9: Marine and Coastal Ecology paragraph 9.5.3.21. Confirmed records derived from the environmental baseline surveys of the Near-Field Study Area are discussed in paragraph 9.5.7.11-9.5.7.13. No Annex I biogenic reef of *S. spinulosa*, or its congener *Sabellaria alveolate*, was observed across the subtidal, shallow subtidal, and/or intertidal areas.

3.7.1.2 Only discrete *Sabellaria spinulosa* aggregations were observed at two separate transect (T_018 and T_026) locations along the ECC, some distance from one another. Within both of these transects, it was observed as a single occurrence. The assessment of these aggregations, presented in the ES, followed that of Gubbay (2007) and concluded that, due to their limited extent, these examples were not deemed to qualify as reef.

3.7.1.3 Patchiness (percentage cover[5]) is a feature of *S. spinulosa* reefs, and thus complete coverage would not be expected across a reef. Under Gubbay (2007), an area that has patchiness of <10%, in combination with area extent of <25m^2 is defined as 'not a reef'.

3.7.1.4 This measure of patchiness is presented by Jenkins *et al.* (2018), as being a measure of density rather than "*true patchiness*". The definition of "*true patchiness*" is defined as *"a value to represent the propensity of S. spinulosa reef to be clustered together rather than to grow uniformly and randomly everywhere".*

3.7.1.5 The updated method proposed by Jenkins *et al.* (2018) for calculating "*true patchiness*" is to count presence/absence, for each 5-second video segment along a transect tow. A patch is defined as a continuous sequence of values of 1, which ends in a value of 0 (see Jenkins *et al.* (2018) for full methodology).

3.7.1.6 The updated methodology of Jenkins *et al.* (2018), based on the earlier work by Gubbay (2007), had not been applied in the assessments in the ES. Across the transects, drop down camera (DDC), not video data, was collected, so a re-assessment could not be undertaken. However, in consideration that of the 27 stills taken at T_018, and of the 48 at T_026, only a single occurrence of *S. spinulosa* aggregations was observed for each transect, this indicates a very low patchiness. As such, the conclusion of the ES, that there is no Annex I biogenic reef present within the Near-Field Study Area remains valid.

3.8 Classification of Annex I Subtidal Sandbanks

3.8.1 Overview

3.8.1.1 This section describes the sandbank feature that had been identified via EIA characterisation surveys outside of the boundary of the Pembrokeshire Marine SAC, intersecting the ECC at ~KP15-KP18. This feature had been assigned a 'Potential' confidence score as an Annex I sandbank. Following consultation, a re-assessment of this feature has been undertaken, to provide further clarification and confirm if it is deemed to represent a 'Potential' Annex I sandbank.

3.8.2 Data Sources

3.8.2.1 To undertake a re-assessment of the 'potential' Annex I sandbank identified outside of the Pembrokeshire Marine SAC, the following data sources and documentation were consulted and re-reviewed:

- ES Volume 1 Chapter 6: Coastal Processes;
- ES Volume 1 Chapter 9: Marine and Coastal Ecology;
- ES Volume 3 Technical Appendix 9.1: Integrated (Geophysical and Habitat Assessment) Technical Report;
- ES Volume 3: Technical Appendix 9.2: Marine and Coastal Environmental Baseline Technical Report;
- Erebus Project – Preliminary Table of Seabed Interventions (RPL_ERE-A02) Rev.07;
- ERE-CAB-WOC-CBL-ELE-003 Export Cable Installation and Protection Footprint – Preliminary Charts Rev.A04;

[5] Percentage cover of consolidated tubes within overall spatial extent of reef.

- Pinder, J. (2020). Method for creating version 3 of the UK Composite Map of Annex I Sandbanks slightly covered by seawater all of the time. Document Version 3. Revised 24/04/2020;
- European Commission (2013). Interpretation Manual of European Union Habitats - EU28;
- JNCC (2019). Annex I Sandbanks in the UK version 3 – 2019 (Public) Polygons; and
- JNCC (2022b). 1110 Sandbanks which are slightly covered by sea water all the time.

3.8.3 Baseline Data and Original Assessment

<u>EIA Characterisation Surveys</u>

3.8.3.1 Environmental and habitat benthic surveys were undertaken for the Project, in 2020, in order to characterise the study area for EIA purposes. Geophysical and ground truthing data were reviewed to assess against the descriptors of Annex I sandbanks. Geophysical data were mainly used to determine topography, while ground truthing data were used to assess sediment type and composition, and the presence of key flora and fauna.

3.8.3.2 Sediment grab samples, taken across the 'Potential' feature (corresponding with stations ST28-ST31), were all dominated by sands, with varying proportions of gravel and some muds. In comparison, samples taken from Turbot Bank almost completely comprised sands (>90%).

3.8.3.3 Bathymetric data indicate that the top of the 'Potential' feature is approximately 38 m below Chart Datum at its shallowest point.

3.8.3.4 The 'Potential' sandbank feature was predominantly identified as belonging to the following European Nature Information System (EUNIS) biotopes:

- A5.25 (fine sand);
- A5.14 (coarse sediments); and
- A5.44 (mixed sediments) (partially around KP18).

3.8.3.5 These sediment characteristics placed this feature within the classification type of "gravelly sands" for Annex I sandbanks (JNCC, 2022b).

3.8.3.6 The Valued Ecological Receptors (VER) assigned to the 'Potential' feature were:

- VER I (Littoral to circalittoral very coarse sediments subject to wave action);
- VER L (Circalittoral fine sand/muddy sand).

3.8.3.7 Macrofauna abundances, sampled by grab within the ECC at the Annex I sandbank Turbot Bank and the 'Potential' sandbank, were similar at ≤55 individuals per station. However, macrofauna diversity was recorded to be greater overall across the 'Potential' feature (<40 taxa), than at Turbot Bank (<11 taxa).

<u>Identification of Annex I Sandbanks</u>

3.8.3.8 For the assessment, Annex I sandbanks were characterised using the three descriptors outlined by Pinder (2020):

- Topography;

- Substrate/vegetation; and
- Proximity to known sandbanks/similarity in benthic community.

3.8.3.9 Two areas of sandy habitat likely to be Annex I sandbanks had been identified along the ECC. The first was identified as intersecting the known Turbot Bank Annex I sandbank feature, and was assigned a ‘High’ confidence score. The second, was identified at ~KP15-KP18, and was assigned a ‘Potential’ confidence score. Although it was deemed to meet the topographic and sedimentary criteria, this lower score was determined due to the lack of known adjacent sandbanks.

3.8.4 Annex I Sandbanks Definition and Interpretation

3.8.4.1 The definition of Annex I sandbanks is:

> *“Sandbanks are elevated, elongated, rounded or irregular topographic features, permanently submerged and predominantly surrounded by deeper water. They consist mainly of sandy sediments, but larger grain sizes, including boulders and cobbles, or smaller grain sizes including mud may also be present on a sandbank. Banks where sandy sediments occur in a layer over hard substrata are classed as sandbanks if the associated biota are dependent on the sand rather than on the underlying hard substrata. “Slightly covered by sea water all the time” means that above a sandbank the water depth is seldom more than 20 m below chart datum. Sandbanks can, however, extend beneath 20 m below chart datum. It can, therefore, be appropriate to include in designations such areas where they are part of the feature and host its biological assemblages.”* (European Commission, 2013).

3.8.4.2 From the above definition, “*Sandbanks can, however, extend beneath 20m below chart datum.”* and *“ It can, therefore be appropriate to include in designations such areas where they are part of the feature and host its biological assemblages*” is interpreted to mean that a shallower sandbank (<20 m) can extend to depths deeper than 20 m, and if these features at deeper depths form part of the shallower feature (e.g. a continuous extension), then they are classified as Annex I.

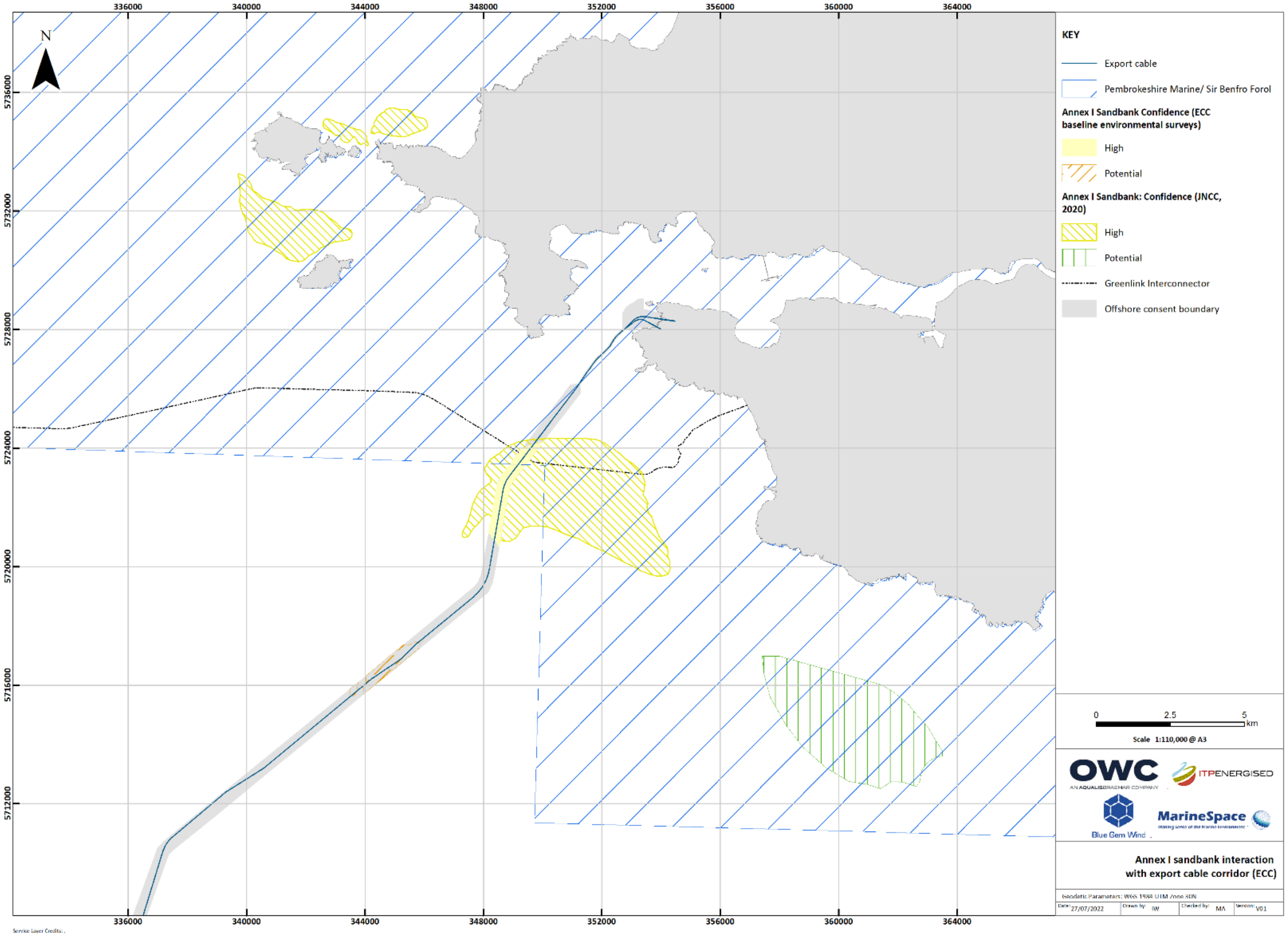
3.8.4.3 The ‘Potential’ feature identified from the from baseline surveys is not connected, or close to the shallower Turbot Bank (~5 km distant), and is located in deeper waters, where at its shallowest point it is approximately 38 m below Chart Datum.

3.8.5 Current Known Extent of Annex I Sandbanks

3.8.5.1 The JNCC dataset (shapefiles) for Annex I Sandbanks in the UK shows the ‘Potential’ and ‘High’ confidence mapped extents of Annex I sandbanks, within the boundaries of the UK continental shelf (JNCC, 2019b). This dataset has been supplemented with data received from Statutory Nature Conservation Bodies (SNCBs) and reassessed for confidence, based upon the suitability against the key sandbank descriptors (described by Pinder, 2020).

3.8.5.2 Figure 3-1 below shows that the latest JNCC data do not predict any ‘Potential’ sandbanks near to, or overlapping the ‘Potential’ feature, that had been identified through the baseline surveys.

Figure 3-1: Annex I sandbank extent overlaid with the Project baseline surveys of the ECC



3.8.6 Re-Assessment

3.8.6.1 Following the methods outlined by Pinder (2020), a re-assessment of the 'Potential' feature identified at ~KP15-KP18 is presented below.

3.8.6.2 As summarised above, three descriptors can be applied to assess if a delineated feature meets the criteria of an Annex I sandbank:

- **Topography**, i.e. the shape and depth of the seabed is consistent with the Annex I definition. Annex I sandbanks can be formed as *Sandy mounds* or *Tidal sandbanks*;
- **Substrate or vegetation**, i.e. the substrate or vegetation type is consistent with that of the Annex I definition; and
- **Proximity to Sandbanks and similarity of benthic communities**, i.e. if the seabed adjacent to Annex I Sandbank has similar benthic communities to those on the Annex I sandbank, this may indicate an extension of the feature.

Suitability

3.8.6.3 The feature identified between KP15-18 was re-assessed to see if it is fell under the categories of "*suitable*", "*less suitable or need more data*", or "*unsuitable*" (see Table 1 in Pinder (2020)).

3.8.6.4 For topography, the feature is determined to be **unsuitable** as the top of the bank is not in depths <20 m, as the bathymetric data across the ECC and surrounding seabed indicates that depths are no shallower than 38 m.

3.8.6.5 For substrate/vegetation type, the feature is determined to be **suitable**, as the sediments sampled across the ECC between ~KP15-KP18 comprise mainly sandy sediments (≥50%), and surrounding habitat is predicted to be 'offshore circalittoral sand' (see ES Volume 2 Figure 9.3). Furthermore, the associated communities are represented by infaunal assemblages, supported by the sediments, and not by any underlying hard substrata.

3.8.6.6 For proximity to sandbanks and similarity of benthic communities, the feature is determined to be **unsuitable**. Even though the infaunal communities are broadly similar, the seabed is not adjacent to known Annex I Sandbanks, where Turbot Bank is at least 4 km distant.

Confidence Scoring

3.8.6.7 A confidence score was applied to the feature at ~KP15-KP18, based on the determination of suitability of the three descriptors.

3.8.6.8 The definition of confidence is as follows, and as described by Pinder (2020):

- 'High': "*a high level of supporting background data";* and
- 'Potential': "*evidence indicates Annex I Sandbank is present but is insufficient to support high confidence".*[6]

3.8.6.9 A confidence score was assigned following review of Table 2 in Pinder (2020), where the combination of descriptor suitability scores indicates final confidence.

[6] 'Potential' does not indicate either a lack of confidence in the data, or that the area has the potential to support Sandbanks. The latter interpretation of 'Potential' is more consistent with the definition of the 'range' of a habitat (Pinder, 2020).

3.8.6.10 It was determined that the suitability scores assigned against the three descriptors (unsuitable for topography, suitable for substrate, unsuitable for proximity to Annex I sandbanks), did not meet the criteria to be attributed either as a 'High' or 'Potential' sandbank.

Summary and Impact Assessment

3.8.6.11 Following re-assessment of the feature intersecting the ECC ~KP15-KP18, it is determined that it **does not meet the criteria of Annex I sandbanks**.

3.8.6.12 This second feature overlaps the ECC by 1.03 km^2. Along part of this feature, sandwave levelling is predicted to be required. In addition, at the southern end, rock protection is predicted to be required and will thus partially overlap the feature (20% of ECC between ~KP17.2-KP18.5). Following this determination, there is no material change to the current impact assessment regarding this feature, as presented in the ES Volume 1 Chapter 9: Marine and Coastal Ecology, with the assessment focussed on the known Annex I sandbank, Turbot Bank.

3.8.6.13 Within the ES Volume 1 Chapter 6: Marine and Coastal Processes, this secondary feature has been listed as an Annex I, however, within the impact assessment, only Turbot Bank has been assessed. As such, following this determination, there is no material change to the current impact assessment presented in the ES regarding this feature.

3.9 Introduction and Colonisation by Invasive Non-Native Species

3.9.1 Overview

3.9.1.1 The risk of introduction and subsequent colonisation by Invasive Non-Native Species (INNS) of Project infrastructure and surrounding habitats is assessed in ES Volume 1, Chapter 6 for the construction, operation and maintenance (O&M), and decommissioning phases of the Project (see ES, Volume 1, Chapter 6 Sections 9.6.3-9.6.4). Following the formal consultation response, an additional assessment of the risk of INNS was identified as required, to be informed further by the ES Volume 3 Technical Appendix 9.4: Offshore Invasive Non-Native Species Plan, hereafter referred to as the Offshore INNS Plan).

3.9.1.2 The below sections present a summarised re-assessment of the expected impact from the introduction of, and subsequent colonisation by INNS, of Project infrastructure.

3.9.2 Baseline

3.9.2.1 A review of the INNS already understood to be present, or likely to be in the region was informed by the environmental baseline surveys and additional desk-based reviews presented in the Offshore INNS Plan. Of the 46 INNS reviewed, the following 12 species were identified as having 'possible', 'likely' or 'certain' presence within the area, and are also of either 'high' or 'medium' risk, requiring surveillance.

- *Asterocarpa humilis* (compass sea squirt): accepted records within Milford Haven*;*
- *Caprella mutica* (Japanese skeleton shrimp): recorded from subtidal grab surveys in Milford Haven;
- *Crepidula fornicata* (slipper limpet): well-established population within Milford Haven and to the south;

- *Diadumene lineata* (orange striped anemone): recorded within Milford Haven and along the south coast of Wales;
- *Didemnum vexillum* (carpet sea-squirt): family identified within Project-specific subtidal surveys, however, this recording may represent a different genus or species. Species itself not confirmed in Pembrokeshire;
- *Ficopmatus enigmaticus* (Australian tubeworm): several accepted records in Milford Haven and southwest Wales;
- *Grateloupia turuturu* (Devil's tongue weed): present in Pembrokeshire waters, and known to be present in Milford Haven.
- *Magallana gigas* (Pacific oyster): Several accepted records within Milford Haven;
- *Sargassum muticum* (japweed): reported as present in areas overlapping the ECC and landfall. Recorded in grab samples in the deep channel of Milford Haven. Present along the south and west coast of Wales;
- *Styela clava* (leathery sea squirt): Several accepted records within Milford Haven, with distributions along the south and west coasts;
- *Undaria pinnatifida* (wakame): Present within Pembrokeshire, and established within Milford Haven; and
- *Watersipora subatra* (red ripple bryozoan): Several accepted records within Milford Haven since 2014.

3.9.2.2 Milford Haven is a busy waterway for ships and recreational vessels, and it is expected that a high number of INNS records will be reported from this area.

3.9.2.3 The environmental conditions of the Project area may be suitable for supporting the natural spread of INNS. Much of the Near Field Project Study Area is almost entirely offshore, and the export cable landfall is at West Angle Bay where there is little freshwater input, thus there are limited barrier effects from salinity variations. The strong tidal currents in the region will also increase the potential spread of pelagic INNS. From the array area, moving inshore, there is an increase in tidal excursion along the ECC towards the coastline (to 18-19 km), but then decreases within Milford Haven itself. There may be an increased risk of natural dispersal of INNS within the nearshore areas of the Project.

3.9.2.4 There are no pre-existing anthropogenic structures present in the Near Field Study Area, excluding a single subsea cable (SOLAS) that runs through the offshore array area. However, this structure is buried beneath the seabed and is thus of minimal risk to the spread of INNS.

3.9.3 Relevant Project Parameters and Mitigation

3.9.3.1 As presented in Table 9.23 of the ES Volume 1 Chapter 9: Marine and Coastal Ecology, the maximum offshore construction period will be 8 months, during which time there will be increased vessel activity in the area, potentially increasing the risk of spread of existing INNS from the port of Milford Haven, or the introduction of new INNS into the area.

3.9.3.2 The amount of Project infrastructure proposed to be installed (semi-submersible floating platforms, anchors, mooring lines, cables and protection etc.) will result in 368,998 m^2 (0.37 km^2) of maximum surface area, that may be available for colonisation by marine INNS (refer to the Offshore Marine Plan for a full breakdown of surface areas available). Please note, that this value of 0.37 km^2 is sourced from the Offshore Marine Plan, and the value of 0.50 km^2, as presented in Table 9.21 of the ES Volume 1 Chapter 9 Marine and Coastal Ecology is now superseded. However, it can be determined that a reduction in total area from 0.5 km^2 to 0.37km^2, means that the existing impact assessment remains valid, and precautionary.

3.9.3.3 The assessment in the Offshore Marine Plan determined that there was an overall greater risk of introductions of INNS via vessels, semi-submersible floating platforms and any areas of export cable protection, compared with areas of array cable protection and/or the mooring lines located within the array area.

3.9.3.4 The O&M phase, and thus the period of time that the infrastructure will be in the marine environment, is expected to be 25 years. During the O&M phase, up to 6 vessels visits per turbine, per year are predicted, with 2 weeks of vessels on site, per cable repair/remediation event. One major O&M campaign is predicted each year (tow back to port).

3.9.3.5 The long-term O&M phase may provide the potential for colonisation and establishment of INNS on the artificial surfaces, and for further introductions of INNS into the area, via vessel activities during maintenance works.

3.9.3.6 The total area available for potential colonisation by INNS is 0.4% of the 93.18 km^2 near-field Study Area. However, as described in ES Volume 1 Chapter 9: Marine and Coastal Ecology (paragraph 9.6.3.1), offshore wind farms can act as ‘stepping stones’ for INNS, providing a network of substrates to exploit and increase their distribution. External cable rock protection will be placed along several locations; from the HDD exit points at the landfall (at ~KP 0.6), along the ECC, and in the array area (see ES Volume 3 Figures 13a-c).

3.9.3.7 Project embedded mitigation includes the development and implementation of the Offshore INNS Plan, which provides a framework for management of biosecurity issues and invasive species for the Project duration, and will include compliance with relevant guidance regarding ballast water. These measures will reduce the overall risk of introduction.

3.9.4 Construction

3.9.4.1 In consideration of the above, whereby the Project will have a short-term construction period (<8 months), is near to a waterway with established INNS present, but the amount of surface available for colonisation is relatively limited (0.37 km^2), it is concluded that the overall magnitude of impact from the introduction of INNS during the construction phase for the Project is **low.**

3.9.4.2 It is difficult to predict the exact nature of potential impacts from the introduction of INNS as associated sensitivities of, and interactions with, existing benthic communities/species can be complex and habitat/species/community specific. It is assessed on a precautionary basis, however, that the sensitivity of native species and associated habitats to introduction of INNS is **medium**.

3.9.4.3 In summary, the low magnitude of impact combined with the medium sensitivity of the receptor results in a **minor adverse** effect on benthic receptors, which is not significant in EIA terms.

3.9.4.4 The re-assessment results in no material change to the original assessment in the ES, with the overall assessment of minor adverse remaining valid.

3.9.5 Operation

3.9.5.1 In consideration of the above Project information, whereby the Project will have a long-term O&M period (<25 years) and provides potential connectivity between the landfall and areas offshore via cable rock protection; however, only provides a limited area for colonisation and risk of introduction will arise from only a small increase in vessel activity; it is concluded that the overall magnitude of impact from introduction and colonisation of INNS during the O&M phase for the Project is **low**

3.9.5.2 As described above, it is difficult to predict the exact nature of potential impacts from INNS, as associated sensitivities of, and interactions with, existing benthic communities/species can be complex and habitat/species/community specific. It is assessed on a precautionary basis, however, that the sensitivity of native species and associated habitats to introduction of INNS, and colonisation of infrastructure by INNS, is **medium**.

3.9.5.3 In summary, the low magnitude of impact combined with the medium sensitivity of the receptor results in a **minor adverse** effect on benthic receptors, which is not significant in EIA terms.

3.9.5.4 The re-assessment results in no material change to the original assessment in the ES, with the overall assessment of minor adverse remaining valid.

3.10 Colonisation of Infrastructure by Native Species

3.10.1.1 The colonisation of infrastructure by non-INNS (e.g. native) species during the O&M phase was assessed in the ES Chapter 9: Marine and Coastal Ecology (see paragraph 9.6.3.66 – 9.6.3.74), where it was overall assessed as having minor beneficial effect, and therefore, not significant in EIA terms. Following the formal consultation response, this impact pathway has been re-reviewed and summarised below.

3.10.1.2 The total surface area available for colonisation is 368,998km^2 (0.37 km^2), which represents 0.40% of the Near-Shore Study Area and 0.03% of the Far-Field Study Area, representing a limited spatial extent. During the O&M phase, up to 6 vessel visits per turbine, 2 weeks of vessel activity per cable repair/remediation event, and up to 1 major O&M campaign per year, are predicted, which presents a low risk of introductions via vessel activities, and which will be further mitigated though embedded INNS control measures.

3.10.1.3 Although the O&M period is long-term, at a maximum of 25 years, and colonisation is expected to occur, the rate of settlement and establishment is expected to be variable, and dependant on surface texture, orientation and position. In consideration of the limited spatial extent of available surfaces, the low frequency of vessel activity, but the long-term O&M period and the environmental conditions that may naturally support dispersal and colonisation of species, the magnitude of potential impact is overall determined to be **low**.

3.10.1.4 As described in the ES, there are beneficial effects of the introduction of hard structures in the marine environment, where native species may colonise (e.g. increased habitat complexity and biomass, and ‘reef effects’). However, it is interpreted that this, in combination with a localised change in habitat from a loss of soft, to hard substratum, will overall result in adverse effects to benthic communities and habitats; and a **medium** sensitivity is determined.

3.10.1.5 The low magnitude of impact, in combination with the medium sensitivity of the benthic receptor group, results in a **minor adverse** effect and, therefore, not significant in EIA terms.

3.10.1.6 Following the above re-assessment, this determination of minor adverse effect has been presented in Table 3-4 (Section 3.13 below), the summary of effects for marine and coastal ecology.

3.11 Climate Change

3.11.1 Overview

3.11.1.1 Following the formal consultation response following the review of ES Volume 1 Chapter: 28: Climatic Change, Major Accidents and Disasters, a request has been made for consideration of the adaption of benthic habitats to future climate change that may occur over the lifetime of the Project, assessed alongside any impacts to these habitats arising from the Project itself (e.g. long-term habitat loss).

3.11.1.2 This has been assessed these under the key themes of:

- Changes in marine processes;
- Increases in sea temperature; and
- Carbon storage, sequestration, and release.

3.11.2 Changes in Marine Processes

3.11.2.1 The potential impacts of climate change include increasing water depth (sea level rise) and changes to wave climate due to changes to winds. Thus, during the lifetime of the Project, this may result in increased storminess and may, in turn, impact benthic ecology.

3.11.2.2 Future climate changes may increase the effects of scour around hard structures, or impact erosional coastlines. If Project infrastructure limits a natural landward retreat, this may create ‘coastal squeeze’, and the subsequent loss of intertidal habitats. Neither HDD nor open-cut trenching options of cable lay will result in any Project infrastructure exposed on the shore, that may interact with these future pressures. However, it is acknowledged that there is uncertainty regarding the future management measures at the landfall, and coastal defence plans (e.g. Shoreline Management Plan 2 (SMP2).

3.11.2.3 ES Volume 1 Chapter 6: Marine and Coastal Processes provides further details on the natural variability, and the effects of potential future changes in climate on marine and coastal processes.

3.11.3 Increase in Sea Temperatures

3.11.3.1 Increases in sea temperature are expected to occur in the future, impacting regional species distributions, and increasing the risk of introduction of INNS. There are no thermal discharges associated with the Project, so any cumulative impacts of warming temperatures will not be increased through Project activities.

3.11.3.2 The risk of INNS from vessel activities, and associated Project works, have been assessed in ES Volume 3 Technical Appendix 9.4: Invasive Non-Native Species Plan.

3.11.4 Carbon Storage, Sequestration, and Release

3.11.4.1 Please note that this formal response has been in part, supported by a recent review of blue carbon habitats in UK Ramsar Sites, prepared for Defra by MarineSpace, that determines the relative importance of benthic habitats for carbon storage and sequestration (currently under final client review).

3.11.4.2 The Project is predicted to interact with a number of benthic habitats, either directly through the placement of Project infrastructure, or indirectly through habitat disturbance. Some of these habitats are ‘blue carbon habitats’, where blue carbon is defined as “carbon stored in coastal and marine ecosystems” and have an important role in climate change mitigation.

3.11.4.3 Those relevant to the Project include:

- Intertidal sandflats and mudflats at West Angle Bay;
- Subtidal sand and mud at the ECC and Array Area;
- Kelp at West Angle Bay; and
- Maerl bed(s) in Milford Haven Waterway.

Kelp Beds

3.11.4.4 Should the contingency option of open cut trenching be undertaken at the landfall, and not the preferred option of HDD, permanent habitat loss is predicted to occur. This loss will be restricted to a negligible area of shallow subtidal rock at West Angle Bay. Rocky substrates themselves are not important in carbon storage (g/m^2) or sequestration (g/m^2/year), but can support kelp, which does provide such function; albeit at lower rates than other habitats. Within the infralittoral at West Angle Bay, large kelps *Laminaria hyperborea* and *Saccorhiza polyschidides* are observed to be attached to rocky substrates and, thus, there may be a localised loss of this blue carbon habitat through open-cut trenching. However, this worst-case scenario of permanent loss is negligible, so any local or regional impact on the carbon functioning of this habitat, that is itself reported to not be of relative importance in this role, is assessed as not significant.

3.11.4.5 If the preferred option of HDD takes places, no permanent loss of these habitats is predicted. However, temporary habitat disturbances will occur across the shallow subtidal during the construction period at the landfall, with increases in SSC and sediment deposition. The infralittoral rock is represented by biotopes belonging to the broad biotope ‘Sediment-affected or disturbed kelp and seaweed communities’ (A3.12). It was assessed that there would be no significant impact to these biotopes from any temporary habitat disturbances and, as such, it can be determined that there will be no degradation of this local blue carbon habitat at West Angle Bay.

Intertidal Sediments

3.11.4.6 Intertidal mudflats and sandflats are both important blue carbon habitats. West Angle Bay is characterised by Annex I intertidal sandflats and mudflats. There is no permanent loss of intertidal sedimentary habitat predicted from Project activities. Any disturbance of this habitat through the contingency option of open-cut trenching, that may result in carbon release, will be temporary and of a short duration, with sediment removed during trenching back filled following cable lay.

Subtidal Sediments

3.11.4.7 Subtidal sands and muds comprise the largest and most widespread blue carbon habitats in Wales, and in the UK overall, with the highest relative carbon storage- largely associated with muds compared to sands (approximately three times).

3.11.4.8 Offshore circalittoral sand is the most dominant and widely spread broad-scale habitat in the Benthic Ecology Study Area and, regionally, is primarily represented by the Valued Ecological Receptor (VER) L (circalittoral find sands/muddy sands). It is predicted that the long-term habitat loss of VER L, from the placement of infrastructure (e.g. cable rock protection), is highly localised; where, within the Array Area and 1 km buffer itself, only 0.11% of VER L will be impacted. Considering this loss during the lifetime of the Project, against the regional scale for this habitat, this represents a negligible impact.

3.11.4.9 Although these habitats are the most extensive of all blue carbon habitats, and offer a wide range of other ecosystem services, they are not the most important at carbon storage and sequestration, when compared with other habitats (e.g. saltmarsh). Furthermore, any physical disturbances of these subtidal sediments during construction or remedial works during operation, are unlikely to result in significant releases and loss of stored carbon from these habitats.

Maerl

3.11.4.10 Maerl is estimated to be the most important blue carbon habitat for carbon storage and sequestration. There is a localised bed(s) in Milford Haven, and in Wales overall this habitat is estimated to have a total extent of just <0.5 km^2. There is no direct impact of the Project on this feature, as it is outside of the Near-Field Benthic Ecology Study Area. Modelling by ABPmer has demonstrated that any impacts of increased SSC and associated deposition of fine sediments during cable installation along the ECC and HDD works, at the landfall, will be of negligible magnitude (see Section 3.4).

Oysters

3.11.4.11 The blue carbon habitat oyster bed (e.g. native oyster *Ostrea edulis*) is not considered here, as this habitat is not reported in the region. Although individuals were identified along the ECC during the baseline surveys, there is no present risk to this blue carbon habitat. However, it will be important to be cognisant of current efforts by NRW Advisory regarding the restoration of *O. edulis* in Milford Haven, where both populations of the native oyster and INNS Pacific oyster *Magallana gigas* are present.

Seagrass and Saltmarsh

3.11.4.12 Saltmarsh is one of the most important blue carbon habitats for carbon storage and sequestration. However, seagrass beds and saltmarsh are not considered here, as both of these habitats are not recorded within the Near-Field Benthic Ecology Study Area. Although seagrass beds and saltmarsh are reported within the Far-Field Benthic Ecology Study Area, no impacts to these habitats are predicted from the Project (e.g. SSC in suspended sediment plumes and smothering). Furthermore, these habitats are present in naturally depositional environments.

3.12 Cumulative Effects Assessment

3.12.1 Milford Haven Maintenance Dredging

3.12.1.1 The NRW Advisory consultation response notes that:

"*Table 30.3 Short-list of Projects included in cumulate effects assessment – Milford Haven Dredging should be scoped in to Marine and Coastal Ecology receptors due to potential indirect impacts from changes in suspended sediment concentration on benthic receptors*".

3.12.1.2 This point is noted, and the Applicant accepts that this should be scoped into cumulative effects assessment. Detailed assessment of the potential for cumulative adverse impacts from these works and the Proposed Development are provided below.

3.12.1.3 Milford Haven is a natural deep-water harbour and serves as one of the premier ports in the UK. Regular dredging activities are required to ensure that the natural deep water channel, and the approaches to Milford Haven Port remain at a safe navigable depth.

3.12.1.4 Maintenance dredging within Milford Haven is licensed to occur at 7 distinct locations. Only 2 of these locations, 'Area A: Mill Bay' and 'Area B: Thorn' are within the 4 km zone of influence for sediment plumes within Milford Haven, as used in screening for the cumulative effects assessment. As will be discussed further below, this zone of influence is considered to be highly precautionary in this case, and actual plume extent is likely to be considerably less extensive than this.

3.12.1.5 The Milford Haven Port Authority Dredging Strategy Document (MHPA, 2021) provides a detailed assessment of potential effects from ongoing dredging within Milford Haven. Dredging in this area may be achieved through several methods: Trailer Suction Hopper Dredger (TSHD), backhoe dredger, cutter suction dredger, grab (or clamshell) dredger, or ploughing. As maintenance dredging involves the removal of sediment deposits, following dredging of virgin material, they are generally unconsolidated in nature, and are therefore typically removed using a TSHD or a grab dredger.

3.12.1.6 Dredging activity causes increased turbidity levels through several pathways. During dredging by TSHD, the most significant is hopper overflow. However, draghead disturbance at the seabed/water interface must also be considered. In shallow water, there is also potential for disturbance by the vessel's own propulsion system. However, this is only expected to present a risk when the propulsion system is close to the seabed, due to the dredger working in very shallow water. MHPA (2021) identifies 4 sites where this may occur; and these do not include the 2 Areas screened into the current assessment.

3.12.1.7 Backhoe and grab dredgers would also cause localised elevations in turbidity due to sediment spill as the loaded bucket or grab is lifted through the water column. However, due to the minimal levels of sediment fluidisation within the bucket during this process, any increases in turbidity will be small, and localised in spatial extent.

3.12.1.8 MHPA (2021) reports that historical (2002) monitoring of dredge plumes at the Texaco (now Valero) site within Milford Haven could be identified up to 1.5 km upstream on a spring flood tide. However, subsequent measures have been introduced to reduce this plume extent.

3.12.1.9 MHPA has introduced contractual restrictions to hopper overflow. Excess water will not be released unless water densities are below a specified density. This ensures that the majority of the dredged mixture remains in the hopper of the vessel. The adoption of this measure has significantly reduced the extent of sediment plumes created within the Milford Haven waterway.

3.12.1.10 Subsequent monitoring during the 2006 and 2010 dredging campaigns recorded turbidity levels that were 10-30 mg/l above background levels, at a point approximately 100 m downstream of dredging operations, and 5-10 mg/l higher than background levels at 500 m downstream.

3.12.1.11 If dredging is carried out using TSHD methods, it will involve discrete periods of dredging, followed by extended periods of no activity, while dredged sediment is transported to the offshore disposal site. TSHD dredging would only be conducted for approximately 4 hours in any 24-hour period. If dredging is carried out using a backhoe dredger loading to barges, then the dredging activity will progress almost continuously, but with a much smaller zone of impact due to low sediment fluidisation within the bucket.

3.12.1.12 The range of natural suspended sediment loading within the Milford Haven water column is typically between 10-50 mg/l (MHPA, 2021). As such, the predicted increases for the maintenance dredging activity are considered to be within the range of natural variation. In addition, it is important to acknowledge the localised spatial extent and temporary nature of any plumes. Section 2 provides additional numerical modelling to assess the magnitude, duration and extent of local increases in Suspended Sediment Concentration (SSC) within, or close to, Milford Haven. It is apparent from this modelling that sediment plumes from cable installation and/or HDD drilling activity will also be associated with low magnitude, highly localised and temporary elevations in SSC. As such, it is considered there is no risk of adverse effects on benthic receptors from this cumulative impact pathway.

3.13 Summary of Effects for Marine and Coastal Ecology

3.13.1.1 Following the formal consultation response, Table 3-4 summarises the significance of predicted effects on benthic receptors during the construction, operation, and decommissioning phases of the Project.

Table 3-4: Summary of Effects for Marine and Coastal Ecology

Description of Effect	Significance of Potential Effect (assuming standard mitigation implemented)		Additional Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial/ Adverse		Significance	Beneficial/ Adverse
Construction					
Temporary habitat disturbance (direct and indirect)	Minor	Adverse	None Required	Minor	Adverse
Temporary increases in suspended sediments/ smothering (indirect)	Minor	Adverse		Minor	Adverse
Introduction of INNS (indirect)	Minor	Adverse		Minor	Adverse
Protection of benthic habitats from fishing restrictions (indirect)	Minor	Beneficial		Minor	Beneficial
Accidental release of pollutants from vessels (direct)	Minor	Adverse		Minor	Adverse
Accidental release of pollutants through disturbance of the sediments (indirect)	Minor	Adverse		Minor	Adverse

Description of Effect	Significance of Potential Effect (assuming standard mitigation implemented)		Additional Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial/ Adverse		Significance	Beneficial/ Adverse
Operation					
Long-term and permanent habitat loss (direct)	Minor	Adverse	None Required	Minor	Adverse
Temporary habitat disturbance (direct)	Minor	Adverse		Minor	Adverse
Temporary increases in suspended sediments/ smothering (indirect)	Minor	Adverse		Minor	Adverse
Colonisation of infrastructure by INNS (indirect)	Minor	Adverse		Minor	Adverse
Colonisation of infrastructure by marine organisms (non INNS) (indirect)	Minor	Adverse		Minor	Adverse
Protection of benthic habitats from fishing restrictions (indirect)	Minor	Beneficial		Minor	Beneficial
Accidental release of pollutants from vessels (direct)	Minor	Adverse		Minor	Adverse
Accidental release of pollutants through disturbance of the sediments (indirect)	Minor	Adverse		Minor	Adverse

Description of Effect	Significance of Potential Effect (assuming standard mitigation implemented)		Additional Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial/ Adverse		Significance	Beneficial/ Adverse
EMF and heat from electrical cables (direct)	Minor	Adverse		Minor	Adverse
Long term changes to physical processes (indirect)	Minor	Adverse		Minor	Adverse
Decommissioning					
Temporary habitat disturbance (direct and indirect)	Minor	Adverse	None Required	Minor	Adverse
Temporary increases in suspended sediments/ smothering (indirect)	Minor	Adverse		Minor	Adverse
Introduction of INNS (indirect)	Minor	Adverse		Minor	Adverse
Accidental release of pollutants from vessels (direct)	Minor	Adverse		Minor	Adverse
Accidental release of pollutants through disturbance of the sediments (indirect)	Minor	Adverse		Minor	Adverse

Chapter 4 Fish and Shellfish Ecology

4.1 Introduction

4.1.1.1 The following sections set out the response to the NRW Advisories comments on fish and shellfish ecology, specifically ghost fishing.

4.2 Ghost Fishing Impact Assessment (Operation and Maintenance)

4.2.1.1 The semi-submersible floating platforms, mooring and hang-off cables, anchor points and other associated cables and scour protection measures associated with the Project have the potential to snag fishing gear. Gear types used within the region include lines, pots and nets. This ghost/derelict fishing gear may remain attached to Project infrastructure, resulting in the entanglement and potential injury, or mortality, of fish and shellfish. Larger fish species have a higher entanglement risk due to their size, with the majority of these larger fish species likely to be elasmobranchs.

4.2.1.2 Studies on the impacts of ghost-fishing on elasmobranchs within the Celtic Sea are limited. However, derelict fishing gear is known to result in the mortality of elasmobranch receptors, with a global assessment indicating that ghost-fishing gear was responsible for 74% of elasmobranch entanglement events recorded within scientific studies (Parton *et al.*, 2019).

4.2.1.3 Stelfox *et al*. (2016) suggest that elasmobranchs such as the small tooth sawfish *Pristis pectinata* may be more vulnerable to ghost-fishing due to their physiology, with an elongate toothed rostrum presenting an increased snagging risk, however elasmobranchs with these features are not known within the Project area. It is more likely that the ghost-fishing of elasmobranchs will occur as a result of individuals predating on smaller species attracted to discarded gear, as a result of fish aggregating device (FAD) effects (see ES Volume 1 Chapter 10: Fish and Shellfish, Fish aggregating device and collision effects). When considering marine megafauna, the impacts of ghost-fishing in the marine environment are better understood, with this impact being considered further within Section 6: Marine Mammals, of this SEI report.

4.2.1.4 The impact of lost pots and traps on fish and shellfish receptors is thought to be low in UK waters. Whilst these types of gear are more likely to impact smaller individuals, mortality rates are understood to be low (Brown and Macfadyen, 2017). This is likely to be a result of low gear loss rates and high retrieval rates, as well as these gear types often allowing for the escape of many species.

4.2.1.5 Garavelli (2020) recommends monitoring measures for mooring systems, using ROVs to allow for the identification of any derelict fishing gear that has become attached to Project infrastructure. The PDE specifies that ROV inspections will be undertaken during the Project lifetime, and will allow for the removal of gear should it be required. Therefore, the magnitude of this impact is considered negligible.

4.2.1.6 Should entanglement or trapping occur to fish or shellfish receptors, and they are unable to escape, there is the potential for injury or death to the individual. Therefore, the sensitivity of all fish and shellfish receptors is considered high.

4.2.1.7 Therefore, as a result of the negligible magnitude but high sensitivity, ghost-fishing within the Project area is considered to result in a **minor adverse** effect, which is not significant in EIA terms.

Chapter 5 Offshore Ornithology

5.1 Introduction

5.1.1.1 The following section provides supplementary environmental information and additional detailed responses to specific queries raised by NRW Advisory, JNCC, RSPB and The Wildlife Trust, via their formal consultation response to the Project Environmental Statement (ES) and Report to Inform Appropriate Assessment (RIAA). The ES was submitted to relevant bodies in December 2021, alongside applications for a Marine Licence and Section 36 consent. The key points raised by NRW Advisory, JNCC, RSPB and The Wildlife Trust in their response related to the following:

Non-Identified apportioning

5.1.1.2 Treatment of birds which were unidentified to species level during baseline surveys (termed ‘non-ID birds’). Abundance and density estimates for these non-ID birds had been presented separately by species group, whereas the developing recommendation from the Statutory Nature Conservation Bodies (SNCBs) is that they should be ‘apportioned’ by species and added to the identified birds for inclusion in assessment.

Collision risk modelling (CRM)

5.1.1.3 There were concerns about the collision estimates taken forward for assessment being based on Option 1 using the site-specific flight height data. This had simply been done as it was apparent from comparison of the range of outputs that Option 1 was clearly ‘worst-case’ (ES Volume 3, Technical Appendix 11.3: Collision Risk Modelling). Advice was also clarified in respect of CRM input parameters, although it makes very minor difference to the submitted CRM. Key differences relate mainly to gannet: application of a nocturnal activity factor; use of a ‘default’ flight speed; as well as that calculated in Langley and Votier (2021), based on Grassholm tracking data; and using ‘gliding’ flight rather than ‘flapping’.

Displacement assessment

5.1.1.4 There were also concerns about displacement assessment being based on a ‘worst case’ estimate from the submitted displacement matrices, rather than a range of values. However, the full range of values had been submitted for reference, for each species and each identified season (breeding/non-breeding), with the choice of worst case for each species explained and discussed (Tables 10 - 26 in ES Volume 3, Technical Appendix 11.4: Displacement Analysis).

5.1.1.5 NRW followed up this advice, with its request (29 June 2022) for Supplementary Environmental Information (SEI), raising the following matters to be addressed:

Request for reassessment

5.1.1.6 "*Baseline data must be reanalysed to include partially identified birds that were previously excluded from the analysis (namely gulls and auks) and all models then rerun as per JNCC and NRW Advisory's comments. Modelling should include the assessment of the worst-case scenario of 9.5MW along with a variety of variables to include, but not limited to; biometrics, avoidance rates, nocturnal activity and density estimates. For the displacement analysis, birds should be apportioned correctly, and displacement considered for both breeding and non-breeding periods*."

5.1.1.7 This request for reassessment is addressed in Section 5.2 below, which sets out the detail of what has been discussed and agreed with NRW Advisory and JNCC, in relation to offshore ornithology.

5.1.1.8 All other matters raised by NRW Advisory, JNCC, RSPB and The Wildlife Trusts are addressed in the Technical and General Consultation Responses spreadsheet.

5.2 Scope for Offshore Ornithology

5.2.1.1 Two post-application meetings have been held to discuss the approach to reassessment for offshore ornithology and SEI addendum requirements:

- 25 May 2022 - meeting to determine 'next steps'; to discuss the key matters for each receptor raised by NRW Advisory and JNCC in their consultation responses, and to agree the over-arching approach to address outstanding items for each receptor going forward; and
- 28 June 2022 - specific offshore ornithology meeting to discuss the detail of the submitted assessment and how to address the matters of concern raised by NRW Advisory and JNCC.

5.2.1.2 For the latter meeting, MarineSpace and HiDef prepared an 'Ornithology Consultation Clarification Technical Note' (emailed to NRW Advisory and JNCC on 23 June 2022), to help structure the discussion, to consider the key matters being raised, and how they might be addressed in this reassessment.

5.2.2 Key points for discussion from the 'Ornithology Consultation Clarification Technical Note' and confirmed NRW Advisory / JNCC advice on these

5.2.2.1 The following key matters (from the NRW Advisory and JNCC response letters as addressed in the 'Ornithology Consultation Clarification Technical Note') were discussed at the meeting held on 28 June 2022, with follow up advice provided by NRW Advisory and JNCC, to agree the scope of the reassessment work and the methodologies to adopt.

<u>It was proposed that reassessment of displacement impacts would be undertaken for guillemot, razorbill and puffin, including non-ID birds, and following NRW Advisory and JNCC recommendations for displacement assessment and non-breeding season apportioning.</u>

5.2.2.2 NRW Advisory and JNCC welcomed the proposed reassessment and queried the detail of how the non-ID apportioning would be undertaken. HiDef provided a paper (01 August 2022), detailing the methodology and comparing initial outputs. This methodology, as described, is presented in Section 5.3.2 with the initial outputs presented in the following sections. This work confirmed that including the non-ID birds makes a substantial difference to auk abundance estimates, but no significant difference to kittiwake or lesser black-backed gull density estimates.

5.2.2.3 Reassessment of displacement impacts for the auks is presented in Section 5.3.3

5.2.2.4 Non-ID apportioning was not required for gannet (where it is possible to assign all recorded individuals to species level) and was reviewed for great black-backed gull, herring gull and northern fulmar, where negligible densities of birds had been recorded across the two years of digital aerial surveys (ES Volume 3, Technical Appendix 11.1: Baseline Data).

<u>It was proposed to recalculate the mortality estimates for gannet, lesser black-backed gull and kittiwake, using data from the submitted ES and following NRW Advisory and JNCC recommendations on collision risk modelling, displacement assessment and non-breeding season apportioning.</u>

5.2.2.5 Recalculated mortalities for lesser black-backed gull and kittiwake were presented in the clarification note and are included, for this SEI, in Appendix A: Offshore Ornithology.

5.2.2.6 Further to discussion at the meeting, CRM has been remodelled for gannet, applying the advised 70% reduction to input densities, as presented in Section 5.4, below. A range of displacement mortality estimates is also considered, with an upper limit based on a 10% mortality rate.

<u>Confirmation was sought that great black-backed gull, herring gull and northern fulmar could be screened out of the reassessment as the conclusions of negligible impact for each species would not change even with inclusion of non-ID birds.</u>

5.2.2.7 This was confirmed by NRW Advisory in its follow up emails dated 13 and 14 July 2022; and by JNCC in its follow up email dated 30 June 2022.

Confirmation was sought that Manx shearwater, Balearic shearwater and European storm-petrel could also be screened out of the reassessment, based on advice from NRW Advisory in their response of 21 April 2022.

5.2.2.8 NRW Advisory and JNCC confirmed at the meeting (28 June 2022) that Manx shearwater, Balearic shearwater and European storm-petrel could be screened out of the reassessment.

Advice was sought on whether sabbatical birds should be considered in offshore ornithology impact assessments in Welsh waters?

5.2.2.9 At the meeting. NRW Advisory and JNCC advised that an assessment with no consideration given to sabbatical birds would be accepted, however, noted that accounting for sabbatical birds would result in a small increase in 'headroom' (i.e., reduce overall impact significance).

NRW Advisory and JNCC have requested that assessment of collision risk is to be based on Option 2 CRM outputs for all species using generic flight height data (responses of 21 and 22 April 2022). The Applicant has confirmed that the 9.5 MW turbine scenario is no longer part of the design envelope so that the 14 MW turbine scenario is now the established CRM worst-case (largest number of turbines and largest overall rotor-swept area).

5.2.2.10 HiDef sought clarification that no CRM remodelling would be required, based on the overwhelming reduction in collision estimates when using Option 2 (as compared to Option 1). The very minor differences in CRM input parameters proposed by NRW Advisory and JNCC would not result in any higher levels of impact beyond the worst-case already assessed.

5.2.2.11 At the meeting. NRW Advisory and JNCC confirmed that CRM remodelling was not required, but that it should be made clear for the record that a few of the input parameters used in the modelling are not what would currently be advised.

5.2.2.12 While not required, an updated CRM has been undertaken for gannet (as noted above and presented in Section 5.4). This uses the input parameters currently advised by NRW Advisory and JNCC (as per their responses of 21 and 22 April 2022) and applies the 70% reduction to input densities as advised at the meeting. This recommended reduction takes account of the levels of gannet displacement (macro-avoidance) being recorded at operational offshore wind farms, so that assessment does not double-count estimated collision and displacement impacts.

NRW Advisory and JNCC have requested that displacement assessment be based on a range of displacement mortality estimates at a range of displacement rates and mortality rates, rather than identifying a single 'worst-case' estimate. An upper displacement mortality rate of 10% has been identified in this regard, applied uniformly across species and across seasons.

5.2.2.13 This advice has been followed for the auk reassessment (Section 5.3), gannet reassessment (Section 5.4) and in respect of kittiwake (as presented in Appendix A – Offshore Ornithology, of this SEI report).

Confirmation was sought that the Special Protection Area (SPA) breeding season apportioning, as submitted, could be used for reassessment as NRW Advisory and JNCC had raised no major concerns in this regard, nor made any request for reanalysis (responses of 21 and 22 April 2022).

5.2.2.14 This was confirmed by NRW Advisory and JNCC at the meeting. These breeding season apportioning weightings are presented in Appendix A - Offshore Ornithology of this SEI report.

Recalculated non-breeding season SPA apportioning weightings were presented in the clarification note following NRW Advisory advice (as presented in their 21 April 2022 response), and confirmation sought that this had been interpreted correctly and that the recalculated weightings, as presented, were to be applied in any reassessment.

5.2.2.15 This was confirmed by NRW Advisory and JNCC at the meeting. These non-breeding season apportioning weightings are presented in Appendix A – Offshore Ornithology of this SEI report.

'Thresholds of significance' were also calculated based on JNCC advice (as presented in their 22 April 2022 response) and presented in the clarification note. It is recommended by JNCC that these are used to consider whether population viability analysis (PVA) is required for SPA qualifying interests. The advised thresholds are based on 1% of baseline mortalities, the latter having been calculated by applying (I-adult survival rates) to the most recent SPA population counts.

5.2.2.16 JNCC welcomed the presentation of these thresholds at the meeting, and confirmed its agreement with the figures presented in the note (the calculated figures for baseline mortalities and for the 1% thresholds) in its email dated 27 July 2022. These figures are included in Appendix A - Offshore Ornithology of this SEI report.

5.2.2.17 In its 22 April 2022 response, JNCC also raised the following matter on cumulative/in-combination assessment:

'*Whilst in-combination impacts have been considered to a point, these have not been added to the project alone impacts and taken through the analysis stages, e.g., to be included within the annual impacts taken through the PVA process if appropriate.'*

5.2.2.18 Cumulative/in-combination impacts were discussed at the meeting, with the limitations to any quantitative assessment (and PVA) set out in the clarification note.

5.2.2.19 At the meeting, NRW Advisory suggested that the cumulative/in-combination assessment undertaken for the Awel y Môr offshore wind farm was reviewed for reference. They also advised that the Morlais tidal development site in Anglesey be considered (consented in December 2021), as well as the Hexicon (formerly Wave Hub site) in Cornwall, granted consent to develop a floating offshore wind demonstrator project in November 2020 (the TwinHub project).

5.2.2.20 These reviews have been completed by MarineSpace and HiDef and inform the consideration of these issues presented below, in Section 5.2.5 Cumulative Assessment.

5.2.3 Avian influenza

5.2.3.1 While it has not been specifically discussed with NRW Advisory or JNCC, and cannot be accounted for in this (re)assessment, it seems important to acknowledge the occurrence of avian influenza this year across the UK, including Grassholm Island. Therefore, a short summary of the issue is provided in Appendix A - Offshore Ornithology of this SEI report.

5.2.4 Scope of reassessment

5.2.4.1 In summary, reassessment is provided on the following key issues raised by NRW Advisory and JNCC, as discussed and agreed at the meeting on 28 June 2022, and in follow up advice:

Auk displacement impacts

5.2.4.2 These are reassessed in Section 5.3.3 for guillemot, razorbill and puffin, as qualifying interests of Skomer, Skokholm and Seas off Pembrokeshire SPA, supported by new PVAs for each species at the SPA to consider potential population consequences.

Gannet collision risk and displacement impacts

5.2.4.3 Reassessed in Section 5.4 for gannet as a qualifying interest of Grassholm SPA. No new PVA is required, as the recalculated mortality estimates (collision risk / displacement) fall within the 'worst case' already modelled (99 mortalities) and demonstrated not to result in any long-term impacts on the viability of the gannet population at the SPA (ES Volume 3, Technical Appendix 11.5: Population Viability Analysis).

5.2.5 Cumulative assessment

5.2.5.1 As recommended by NRW Advisory, the submitted ES, RIAAs, and other supporting information, have been reviewed for the following projects to consider the likely risk of cumulative offshore ornithological impacts in combination with the Project. This has been reviewed in the context of PINS Advice Note 17: *Cumulative effects assessment relevant to nationally significant infrastructure projects* and the Project Cumulative Impact Assessment aligns with and is compliant with best practice advice.

Awel y Môr

5.2.5.2 Awel y Môr was submitted to PINS on 20 April 2022, several months after the Project submission to NRW on 21 December 2021.

5.2.5.3 Review of the Awel y Môr RIAA indicates that kittiwake, puffin, Manx shearwater and European storm-petrel have been screened into HRA as qualifying interests of Skomer, Skokholm and Seas off Pembrokeshire SPA. For assessment, the RIAA indicates negligible puffin displacement mortalities apportioned to the SPA (<0.1 bird) and negligible kittiwake collision mortalities likewise apportioned (these latter figures are included for information in Appendix A - Offshore Ornithology, of this SEI report). Only kittiwake collision risk has been assessed at Awel y Môr, and not any potential displacement. There are zero Manx shearwater or European storm-petrel mortalities predicted to arise from Awel y Môr. Altogether, it is concluded that the project will not have any measurable effect on the viability of any seabird populations at Skomer, Skokholm and Seas off Pembrokeshire SPA, and will not be contributing to any cumulative/in-combination impacts in this regard.

5.2.5.4 Gannet are included under HRA for Awel y Môr as a qualifying interest of Grassholm SPA. Here, the RIAA states negligible gannet displacement mortalities apportioned to the SPA (<0.3 bird) and a low degree of collision risk (3.8 mortalities apportioned to the SPA). These estimated gannet mortalities arising from Awel y Môr are included for consideration in Section 5.4. As noted above, no new PVA is required for the Project reassessment, as the total estimated gannet mortalities (the Project, together with Awel y Môr) still fall within the 'worst case' previously modelled.

5.2.5.5 The Awel y Môr RIAA has also been reviewed to check the list of projects included for cumulative / in-combination ornithology assessment, and whether any more data have been identified for these projects, compared with that noted in the ES chapter and RIAA for the Project With the exception of Hexicon TwinHub (now addressed below), all the same Tier 1 projects[7] (built, consented or application) have been assessed for Awel y Môr as for Erebus, and there are no additional Tier 2 (scoping) or Tier 3 (pre-scoping) projects referenced, that weren't also included in the Project long list of development for offshore ornithology assessment.[8]

5.2.5.6 In respect of the Tier 1 projects, the Awel y Môr RIAA states that:

- "*no other plans or projects identified… assessed displacement impacts to guillemot, razorbill or puffin at… Skomer, Skokholm and the Seas off Pembrokeshire SPA*" (p.401, paragraph 814); and that
- "*no other plans or projects identified… assessed displacement impacts to gannet at… Grassholm SPA*" (p.402, paragraph 820).

5.2.5.7 Of the Tier 1 projects listed in Table 29 of the Awel y Môr RIAA, none has undertaken an assessment of collision risk to gannet at Grassholm SPA and, therefore, cumulative impacts against the SPA are not considered further (Awel y Môr RIAA, p.412).

Morlais

5.2.5.8 Potential impacts (such as collision risk) arising from the Morlais tidal development (consented in December 2021), on the three auk species (guillemot, razorbill and puffin), are assessed in Chapter 11 of their submitted ES, Marine Ornithology. These impacts are primarily assigned against the South Stack and Penlas Seabird Monitoring Programme (SMP) sub-colonies: 100% of guillemot recorded on-site are from these sub-colonies, 100% of razorbill, and 81% of puffin. Less than 1% of puffin (and negligible related mortality estimates) are assigned against Skomer, Skokholm and Seas off Pembrokeshire SPA.

5.2.5.9 Therefore, there is no risk of significant cumulative impacts arising from Morlais, in combination with the Project, against the populations of guillemot, razorbill and puffin at Skomer, Skokholm and Seas off Pembrokeshire SPA, of primary concern in the Project (re)assessment.

5.2.5.10 Morlais may potentially give rise to a single (annual) gannet mortality (Section 11.6.6.3 Morlais ES Chapter 11 Offshore Ornithology). Therefore, there is no risk of significant cumulative impacts arising from this project, in combination with Erebus, against the gannet population at Grassholm SPA.

[7] Project tiers as defined in PINS (2019) advice note on 'Cumulative effects assessment relevant to nationally significant infrastructure'.

[8] As advised, this screening was based on the 2,365.5 km foraging distance for Manx shearwater, and thus brought in all UK offshore development as well as the majority of European offshore development (including everything in Irish, French, Danish, German, Polish, Scandinavian, Spanish and Italian waters).

Hexicon TwinHub

5.2.5.11 As advised by Natural England in its response letter (dated 14 December 2018) to the S.36 consent application to develop a floating offshore wind demonstrator project at the Hexicon (formerly Wave Hub site) in Cornwall, a project in this location may result in very minimal increases to mortality rates for gannet at the Flatholm Site of Special Scientific Interest (SSSI), and to lesser black-backed gull and greater black-backed gull at the Isles of Scilly SPA.

5.2.5.12 Therefore, there is no risk of significant cumulative impacts arising from the Hexicon TwinHub proposal, in combination with the Project, against any of the key SPA populations of concern in the Project (re)assessment.

5.2.5.13 As noted above, NRW has closed out cumulative and in-combination issues in respect of Awel y Môr, acknowledging the data limitations that were also flagged by the Project in respect of such assessment. Quantified assessment, as was being suggested by JNCC, is simply not possible due to the lack of data and the fact that none of the consented (and / or built) Tier 1 projects have quantified their impacts against either Grassholm SPA, or Skomer, Skokholm and Seas off Pembrokeshire SPA, the key SPAs assessed in respect of potential 'project-alone' impacts arising from the Project.

5.3 Reassessment – Auk Species

5.3.1.1 As advised in the 'Ornithology Consultation Clarification Technical Note', and agreed with NRW Advisory and JNCC, a reassessment of displacement impacts to the auk species (guillemot, razorbill and puffin) has been undertaken, accounting for the non-ID birds and including a range of displacement mortality estimates not an identified 'worst case'.

5.3.1.2 The approach to non-ID apportioning is explained in Section 5.3.2 and the initial outputs for unapportioned vs. apportioned estimates are presented in Appendix A – Offshore Ornithology (for the auks, these are uncorrected for availability bias).

5.3.1.3 The non-ID apportioned estimates are then taken forward in data analysis following the methods described in ES Volume 3, Technical Appendix 11.1: Baseline Data, and applying the correction factors for availability bias (Section 2.2.2 of that appendix). Updated population estimates for each survey month are presented in Appendix A – Offshore Ornithology of this SEI report.

5.3.2 Non-ID Apportioning

5.3.2.1 Apportioning is used to assign observations to a species which could not be identified to species level during the ID process. For each species group (e.g., large auk), the proportion of each component species (e.g., guillemot and razorbill) present in that group is calculated from the proportion of observations identified to the relevant species. For example, if one survey recorded 200 identified birds in the 'large auk' group and 160 were guillemots and 40 were razorbills, then their proportions are 0.8 and 0.2 respectively. These weightings are then used to assign any unidentified birds in that species group to their relevant species category. For example, if there were 100 unidentified 'large auks', then 80% of those would be assigned to guillemot and 20% would be assigned to razorbill.

5.3.2.2 This can also be done at a behaviour level. For example, if 20% of sitting auks were recorded as razorbills, then 20% of non-identified sitting auks would be assigned to razorbills. The species and species groups (and thus possible weightings) included in this process are limited to those observed within the survey; they are dependent on the ratios of species present in that survey, and how unidentified birds have been categorised by HiDef''s expert ID team.

Data aggregation tool (DAT)

5.3.2.3 Once the data have been processed by the HiDef review and ID teams, the observations for each survey are run through the DAT. First, the observations are trimmed to the specified boundary shapefile to ensure sections of transects which ran outside the area of interest are removed, and counts are not exaggerated.

5.3.2.4 The DAT then evenly splits each transect into 500 m bins or 'sections', and sums the observations for each species group (e.g., large auk) and species level (e.g., guillemot) recorded in each bin. If the bird has not been identified to species level, the species group will be recorded, but the species level will be recorded as 'No ID'. From this process, the total number of observed individuals for each category is aggregated and can be run through the bootstrapping process to calculate unapportioned or apportioned density and population estimates.

Bootstrap methodology

5.3.2.5 To produce density or population estimates (and associated estimates of uncertainty) for the entire survey area, a technique called bootstrapping is used. Firstly, the density of each species is calculated by dividing the unapportioned or apportioned values from the DAT by the area (km). These values are then bootstrapped. Each bootstrap iteration creates a new dataset by randomly selecting a number of transects, which are of no greater length than the actual survey transect length. However, the same value can be selected multiple times and some values may not be resampled at all. This gives a different average density value for each iteration of bootstrapping.

5.3.2.6 This process is repeated 1,000 times, meaning 1,000 unique density estimates are produced and an average calculated. The average density can then be multiplied by the survey area to produce a population estimate.

5.3.2.7 Due to the stochasticity introduced by randomly sampling values during each iteration, the density and population estimates will vary if repeating the full process. Apportioned estimates will generally be greater than unapportioned estimates, as they are estimated on a greater number of birds (identified and unidentified). However, when observations are low, sometimes the unapportioned estimates may be slightly greater than the apportioned ones (less than 5% greater). This will be due to the stochasticity of the bootstrap and the random sampling of the transects.

5.3.3 Auk Displacement Assessment

5.3.3.1 The methodology for displacement assessment is described in Volume 3, Technical Appendix 11.4: Displacement Analysis, following SNCB (2017) guidance. The displacement matrices have been updated, as requested by NRW Advisory, so that they now present displacement mortality estimates for the updated mean seasonal peaks (MSPs) (for each of the auk species and for each season), as apportioned to Skomer, Skokholm and Seas off Pembrokeshire SPA.

Calculation of updated mean seasonal peaks

5.3.3.2 The updated MSPs for guillemot, razorbill and puffin now include the non-ID birds and are based on the mean of the peak monthly population estimates for each season in each year of survey work, as identified in Table 5-1 - Table 5-3. For most species and seasons, the calculation is based on two peak counts, however, for razorbill in their autumn migratory period (August – October) three peak counts have been used. This is because the survey work in this migratory period was split over three years, as well as the peak count in October 2019 being an order of magnitude higher than all other counts in this period.

Table 5-1: Guillemot, calculation of updated mean seasonal peaks

Season	Peak population estimates (including non-ID birds)		MSP
	Date	No. of birds	
Breeding	23-Jul-20	1,175	7,001
	05-Mar-21	12,827	
Non-breeding	22-Oct-19	14,567	28,338
	31-Aug-20	42,108	

Table 5-2: Razorbill, calculation of updated mean seasonal peaks

Season	Peak population estimates (including non-ID birds)		MSP
	Date	No. of birds	
Breeding	04-Apr-20	304	194
	14-May-21	84	
Autumn migration	22-Oct-19	4,380	1,708
	15-Oct-20	744	
	16-Aug-21	0	
Non-breeding	08-Nov-19	960	1,069
	31-Dec-20	1,178	
Spring migration	18-Jan-20	176	896
	16-Jan-21	1,616	

Table 5-3: Puffin, calculation of updated mean seasonal peaks

Season	Peak population estimates (including non-ID birds)		MSP
	Date	No. of birds	
Breeding	04-Apr-20	1,797	1,416
	15-Jun-21	1,035	
Non-breeding	22-Oct-19	197	160
	05-Mar-21	123	

Comparison of mean seasonal peaks

5.3.3.3 Table 5-4 to Table 5-6 provide a comparison of the MSPs used in the original assessment, the updated MSPs accounting for non-ID birds (as calculated in the preceding section), and the updated MSPs as apportioned to Skomer, Skokholm and Seas off Pembrokeshire SPA (shortened to 'SSSoP' in the table titles).

5.3.3.4 The SPA apportioning weightings, as applied, are also presented in each table. The breeding season weightings are those calculated for the original assessment and confirmed as acceptable for use by NRW and JNCC (at the meeting held on 28 June 2022), noted above. These are presented for information in Appendix A – Offshore Ornithology. The non-breeding season weightings are those that have been recalculated based on NRW advice (Appendix A – Offshore Ornithology). Note that the apportioned MSPs are rounded up to the nearest whole bird.

Table 5-4: Guillemot, comparison of mean seasonal peaks used in assessment

Season	Original MSP excluding non-ID birds	Updated MSP including non-ID birds	Apportioning weightings applied	Updated MSP apportioned to SSSoP SPA
Breeding	3,558	7,001	0.754	5,279
Non-breeding	15,324	28,338	0.026	737

Table 5-5: Razorbill, comparison of mean seasonal peaks used in assessment

Season	Original MSP excluding non-ID birds	Updated MSP including non-ID birds	Apportioning weightings applied	Updated MSP apportioned to SSSoP SPA
Breeding	103	194	0.892	174
Autumn migration	1,228	1,708	0.019	33
Non-breeding	556	1,069	0.011	12

Season	Original MSP excluding non-ID birds	Updated MSP including non-ID birds	Apportioning weightings applied	Updated MSP apportioned to SSSoP SPA
Spring migration	460	896	0.019	18

Table 5-6: Puffin, comparison of mean seasonal peaks used in assessment

Season	Original MSP excluding non-ID birds	Updated MSP including non-ID birds	Apportioning weightings applied	Updated MSP apportioned to SSSoP SPA
Breeding	449	1,416	0.997	1,412
Non-breeding	32	160	0.029	5

5.3.3.5 Note that as well as inclusion of the non-ID birds, the substantial increase in the updated puffin MSP is due to the decision to include the peak count of 4 April 2020 within the breeding season. Previously, in the submitted ES, this count had been excluded based on the seasonal definitions provided in Furness (2015); and the breeding season had been determined to start in May. However, the 4 April 2020 count is now included on a precautionary basis for the assessment.

Auk displacement matrices

5.3.3.6 As requested, displacement matrices are provided for each of the auk species, based on the updated MSPs apportioned to Skomer, Skokholm and Seas off Pembrokeshire SPA (shortened to 'SSSoP' in the table titles). This allows for direct and easy comparison of the different SPA mortality estimates for each species, at the full range of possible displacement and mortality rates from 0-100%. The potential range of impacts at upper and lower displacement rates (60% and 40%), and at a range of mortality rates (1-10%), are highlighted in grey in each table, and the numbers in bold are the impact scenarios selected for population modelling (see Section 5.3.4 below).

5.3.3.7 Note that all mortality estimates in the displacement matrices are rounded up to the nearest whole bird, which will result in some over-estimation of impacts where minimal fractions (<0.5) of a bird are involved (particularly relevant to the non-breeding season estimates for razorbill and for puffin).

5.3.3.8 At the higher rates of displacement and of mortality, some of the estimated mortalities for each species exceed the recommended thresholds for undertaking PVA. NRW and JNCC advise basing such decisions (whether to undertake PVA) on a 1% threshold of baseline mortalities. These were calculated for, and presented in, the 'Ornithology Consultation Clarification Technical Note' and confirmed correct by JNCC in its email dated 27 July 2022. The baseline mortalities for the auks are:

- Common guillemot – 33 individuals;
- Atlantic puffin – 36 individuals; and
- Razorbill – 11 individuals.

5.3.3.9 They are included here for reference in Table 5-7 (see Appendix A – Offshore Ornithology, of this SEI report, for more information). For reference, the 1% baseline mortalities, for each of the considered auk species, are presented in Table 5-8 to Table 5-15.

Table 5-7: The number of individuals representing 1% of baseline mortality for auks at Skomer, Skokholm and Seas off Pembrokeshire SPA.

SPA protected feature	Adult survival rate (Horswill and Robinson, 2015)	SPA breeding population (ind.)	Year of census	Baseline mortality	1% baseline mortality (individuals)
Skomer, Skokholm and Seas off Pembrokeshire					
Common guillemot	0.889	29,744	2017-2019	3,302	33
Atlantic puffin	0.906	38,342	2018	3,604	36
Razorbill	0.895	10,694	2018-2019	1,123	11

Table 5-8: Guillemot estimated breeding season displacement mortality, as apportioned to SSSoP

Guillemot Mar-Jul		**Mortality Level (% of displaced birds that die)**												
		0%	**1%**	**2%**	**3%**	**4%**	**5%**	**10%**	**15%**	**20%**	**30%**	**50%**	**80%**	**100%**
Displacement Level (% of all birds on-site)	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	6	11	16	22	27	53	80	106	159	264	423	528
	20%	0	11	22	32	43	53	106	159	212	317	528	845	1,56
	30%	0	16	32	48	64	80	159	238	317	476	792	1,267	1,584
	40%	0	**22**	43	**64**	85	**106**	**212**	317	423	634	1,56	1,690	2,112
	50%	0	27	53	80	106	132	264	396	528	792	1,320	2,112	2,640
	60%	0	**32**	64	**96**	127	**159**	**317**	476	634	951	1,584	2,534	3,168
	70%	0	37	74	111	148	185	370	555	740	1,109	1,848	2,957	3,696
	80%	0	43	85	127	169	212	423	634	845	1,267	2,112	3,379	4,224
	90%	0	48	96	143	191	238	476	713	951	1,426	2,376	3,801	4,751
	100%	0	53	106	159	212	264	528	792	1,56	1,584	2,640	4,224	5,279

Table 5-9: Guillemot estimated non-breeding season displacement mortality, as apportioned to SSSoP

Guillemot Aug-Feb		Mortality Level (% of displaced birds that die)												
		0%	**1%**	**2%**	**3%**	**4%**	**5%**	**10%**	**15%**	**20%**	**30%**	**50%**	**80%**	**100%**
Displacement Level (% of all birds on-site)	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	1	2	3	3	4	8	12	15	23	37	59	74
	20%	0	2	3	5	6	8	15	23	30	45	74	118	148
	30%	0	3	5	7	9	12	23	34	45	67	111	177	222
	40%	0	**3**	6	**9**	12	**15**	**30**	45	59	89	148	236	295
	50%	0	4	8	12	15	19	37	56	74	111	185	295	369
	60%	0	**5**	9	**14**	18	**23**	**45**	67	89	133	222	354	443
	70%	0	6	11	16	21	26	52	78	104	155	258	413	516
	80%	0	6	12	18	24	30	59	89	118	177	295	472	590
	90%	0	7	14	20	27	34	67	100	133	199	332	531	664
	100%	0	8	15	23	30	37	74	111	148	222	369	590	737

Table 5-10: Razorbill estimated breeding season displacement mortality, as apportioned to SSSoP

Razorbill Apr-Jul		Mortality Level (% of displaced birds that die)												
		0%	**1%**	**2%**	**3%**	**4%**	**5%**	**10%**	**15%**	**20%**	**30%**	**50%**	**80%**	**100%**
Displacement Level (% of all birds on-site)	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	1	1	1	1	1	2	3	4	6	9	14	18
	20%	0	1	1	2	2	2	4	6	7	11	18	28	35
	30%	0	1	2	2	3	3	6	8	11	16	26	42	52
	40%	0	**1**	2	**3**	3	**4**	**7**	11	14	21	35	56	70
	50%	0	1	2	3	4	5	9	13	18	26	44	70	87
	60%	0	**2**	3	**4**	5	**6**	**11**	16	21	32	52	84	104
	70%	0	2	3	4	5	7	13	19	25	37	61	97	122
	80%	0	2	3	5	6	7	14	21	28	42	70	111	139
	90%	0	2	4	5	7	8	16	24	32	47	78	125	156
	100%	0	2	4	6	7	9	18	26	35	52	87	139	174

Table 5-11: Razorbill estimated autumn migration displacement mortality, as apportioned to SSSoP

Razorbill Aug-Oct		Mortality Level (% of displaced birds that die)												
		0%	**1%**	**2%**	**3%**	**4%**	**5%**	**10%**	**15%**	**20%**	**30%**	**50%**	**80%**	**100%**
Displacement Level (% of all birds on-site)	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	1	1	1	1	1	1	1	1	1	2	3	4
	20%	0	1	1	1	1	1	1	1	2	2	4	6	7
	30%	0	1	1	1	1	1	1	2	2	3	5	8	10
	40%	0	**1**	1	**1**	1	**1**	**2**	2	3	4	7	11	13
	50%	0	1	1	1	1	1	2	3	4	5	9	13	17
	60%	0	**1**	1	**1**	1	**1**	**2**	3	4	6	10	16	20
	70%	0	1	1	1	1	2	3	4	5	7	12	19	23
	80%	0	1	1	1	2	2	3	4	6	8	13	21	26
	90%	0	1	1	1	2	2	3	5	6	9	15	24	30
	100%	0	1	1	1	2	2	4	5	7	10	17	26	33

Table 5-12: Razorbill estimated wintering displacement mortality, as apportioned to SSSoP

Razorbill Nov-Dec		Mortality Level (% of displaced birds that die)												
		0%	**1%**	**2%**	**3%**	**4%**	**5%**	**10%**	**15%**	**20%**	**30%**	**50%**	**80%**	**100%**
Displacement Level (% of all birds on-site)	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	1	1	1	1	1	1	1	1	1	1	1	2
	20%	0	1	1	1	1	1	1	1	1	1	2	2	3
	30%	0	1	1	1	1	1	1	1	1	2	2	3	4
	40%	0	**1**	1	**1**	1	**1**	**1**	1	1	2	3	4	5
	50%	0	1	1	1	1	1	1	1	2	2	3	5	6
	60%	0	**1**	1	**1**	1	**1**	**1**	2	2	3	4	6	8
	70%	0	1	1	1	1	1	1	2	2	3	5	7	9
	80%	0	1	1	1	1	1	1	2	2	3	5	8	10
	90%	0	1	1	1	1	1	2	2	3	4	6	9	11
	100%	0	1	1	1	1	1	2	2	3	4	6	10	12

Table 5-13: Razorbill estimated spring displacement mortality, as apportioned to SSSoP

Razorbill Jan-Mar		Mortality Level (% of displaced birds that die)												
		0%	**1%**	**2%**	**3%**	**4%**	**5%**	**10%**	**15%**	**20%**	**30%**	**50%**	**80%**	**100%**
Displacement Level (% of all birds on-site)	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	1	1	1	1	1	1	1	1	1	1	2	2
	20%	0	1	1	1	1	1	1	1	1	2	2	3	4
	30%	0	1	1	1	1	1	1	1	2	2	3	5	6
	40%	0	**1**	1	**1**	1	**1**	**1**	2	2	3	4	6	7
	50%	0	1	1	1	1	1	1	2	2	3	5	7	9
	60%	0	**1**	1	**1**	1	**1**	**2**	2	3	4	6	9	11
	70%	0	1	1	1	1	1	2	2	3	4	6	10	12
	80%	0	1	1	1	1	1	2	3	3	5	7	11	14
	90%	0	1	1	1	1	1	2	3	4	5	8	13	16
	100%	0	1	1	1	1	1	2	3	4	6	9	14	18

Table 5-14: Puffin estimated breeding season displacement mortality, as apportioned to SSSoP

Puffin Apr - Aug		Mortality Level (% of displaced birds that die)												
		0%	**1%**	**2%**	**3%**	**4%**	**5%**	**10%**	**15%**	**20%**	**30%**	**50%**	**80%**	**100%**
Displacement Level (% of all birds on-site)	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	2	3	5	6	8	15	22	29	43	71	113	142
	20%	0	3	6	9	12	15	29	43	57	85	142	226	283
	30%	0	5	9	13	17	22	43	64	85	128	212	339	424
	40%	0	**6**	12	**17**	23	**29**	**57**	85	113	170	283	452	565
	50%	0	8	15	22	29	36	71	106	142	212	353	565	706
	60%	0	**9**	17	**26**	34	**43**	**85**	128	170	255	424	678	848
	70%	0	10	20	30	40	50	99	149	198	297	495	791	989
	80%	0	12	23	34	46	57	113	170	226	339	565	904	1,130
	90%	0	13	26	39	51	64	128	191	255	382	636	1,17	1,271
	100%	0	15	29	43	57	71	142	212	283	424	706	1,130	1,412

Table 5-15: Puffin estimated non-breeding season displacement mortality, as apportioned to SSSoP

Puffin Sep-Mar		Mortality Level (% of displaced birds that die)												
		0%	**1%**	**2%**	**3%**	**4%**	**5%**	**10%**	**15%**	**20%**	**30%**	**50%**	**80%**	**100%**
Displacement Level (% of all birds on-site)	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	1	1	1	1	1	1	1	1	1	1	1	1
	20%	0	1	1	1	1	1	1	1	1	1	1	1	1
	30%	0	1	1	1	1	1	1	1	1	1	1	2	2
	40%	0	**1**	1	**1**	1	**1**	**1**	1	1	1	1	2	2
	50%	0	1	1	1	1	1	1	1	1	1	2	2	3
	60%	0	**1**	1	**1**	1	**1**	**1**	1	1	1	2	3	3
	70%	0	1	1	1	1	1	1	1	1	1	2	3	4
	80%	0	1	1	1	1	1	1	1	1	2	2	3	4
	90%	0	1	1	1	1	1	1	1	1	2	3	4	5
	100%	0	1	1	1	1	1	1	1	1	2	3	4	5

5.3.3.10 Although NRW Advisory and JNCC advised considering a range of displacement estimates, at different displacement rates and mortality rates (emails of 02 August 2022 and 28 July 2022, respectively), they did not provide any specific advice on which combination of rates should be taken forward for assessment. Instead, NRW Advisory and JNCC referred to the SNCB advice note on displacement (SNCB, 2017), which states that "*appropriate mortality rates should be selected based on expert opinion and in discussion with SNCBs*". NRW Advisory and JNCC did not give any view on the discussion of the displacement and mortality rates taken forward in the submitted application (Sections 2.1.4 - 2.1.6 of ES Volume 3, Technical Appendix 11.4: Displacement Analysis).

5.3.3.1 The advice received was to apply the 10% mortality rate uniformly across species, yet biologically, one would expect it to vary to account for species ecology and sensitivity to the effects of displacement. Application of a 10% mortality rate to gannet, for example, seems particularly unjustified, considering their very large foraging ranges and efficient gliding flight. While they may show a high level of displacement (a rate of 60% being generally used for assessment) it seems unlikely that they would suffer much energetic cost from this, or that there would be any significant effects on individual fitness. These matters were included for discussion in Section 2.1.6 of ES Volume 3, Technical Appendix 11.4: Displacement Analysis.

5.3.3.2 NRW Advisory and JNCC did not advise on the specific combinations of displacement and mortality rates for auks to take forward in the population modelling (see following section). The chosen displacement rate of 60% was based on expert judgement and taking into account the 'disturbance susceptibility' scores outlined in SNCB guidance (SNCB, 2017), based on Furness *et al.* (2013) and Bradbury *et al.* (2014). Currently, NatureScot and Marine Scotland Science advise upper displacement rates of 60% for auks which aligns with the range presented in the SNCB guidance. However, JNCC advised the use of a 70% displacement rate for the auks on 17 August 2022, one week prior to submission of the SEI. Based on the aforementioned rationale, the below information, and the limited time between the advice being received and submission date it was decided the adopted approach would adequately address SNCB concerns.

5.3.3.3 A 70% displacement mortality rate for the auks has not been advised for any other offshore wind farm projects, to date. An upper limit of 60% (recommended by NatureScot and Marine Scotland Science) has been used in the decision-making for all consented offshore wind farms in Scottish waters. A 50% rate appears to have been used by PINS, in its decision-making for Hornsea Project Three, and review of Awel y Môr confirms that a 50% rate has also been adopted there, at least in relation to the submitted ES.

5.3.3.4 There also needs to be some acknowledgement of the removal of the 9.5 MW turbine scenario at the Project, and reduction in the maximum number of turbines (now seven rather than ten). The only way to account for this in assessment and decision-making, is by using lower rates of displacement and mortality; the turbines will be more widely spaced, or they will occupy a smaller overall footprint, both of which will result in lower overall displacement impacts.

5.3.3.5 For the Project, the MSPs used in assessment (both for the original ES and the ones updated here) have been based on the whole outline array area plus 2 km buffer; the array area is ~43 km^2 (together with the 2 km buffer it is ~109 km^2). Therefore, the buffer area is ~66 km^2, a third larger that the array area itself; so that applying the same rates of displacement and mortality to this larger area (when it is known and acknowledged that these rates in the buffer will be lower than those in the array area) results in a substantial overestimation of displacement mortalities potentially arising.

5.3.3.6 Also, the array area that will eventually be built out for the Project is likely to be much less than that assessed for application. This, again, means that potential displacement mortalities are being overestimated at application stage. For comparison, the array areas for similar small-scale floating offshore wind farms are as follows:

- Hywind (built): five turbines occupying a final array area of 15 km^2;
- Kincardine (built): six turbines occupying a final array area of 8 km^2; and
- Pentland (application): seven turbines occupying a proposed array area of 10 km^2.

5.3.3.7 At the higher rates of displacement and of mortality, some of the estimated mortalities for each species do exceed the recommended thresholds for undertaking PVA. NRW and JNCC advise basing such decisions (whether to undertake PVA) on a 1% threshold of baseline mortalities. These were calculated for, and presented in, the 'Ornithology Consultation Clarification Technical Note' and confirmed correct by JNCC in its email dated 27 July 2022. They are included here for reference (please see Appendix A – Offshore Ornithology of this SEI report).

5.3.4 Population modelling for the auk reassessment

5.3.4.1 PVA is the method for modelling the population-level consequences of estimated mortalities. PVA uses the estimated demographic rates for a population (typically survival and productivity), in a mathematical model, to forecast future levels of a population. In this regard, NE commissioned the Centre for Hydrology and Ecology (CEH) to devise a standard PVA tool for undertaking such modelling (Searle *et al*., 2019). This is currently the SNCB accepted Best Available Technique. The tool constructs a stochastic Leslie matrix and runs through a web-based 'R-Shiny' package in the R computer programming language.

5.3.4.2 PVA is used here to consider the population consequences of estimated displacement mortalities arising from The Project for guillemot, razorbill and puffin, as apportioned to their populations at Skomer, Skokholm and Seas off Pembrokeshire SPA.

Auk displacement mortality estimates for Population Viability Assessment

5.3.4.3 Table 5-16 to Table 5-18 present the impact scenarios selected from the displacement matrices (Section 5.3.3), considering an upper (60%) and lower (40%) displacement rate and a range of mortality rates (1%, 3%, 5% and 10%). These same rates of displacement and mortality are applied to both the breeding and non-breeding seasons, and then the displacement mortality estimates summed to give an annual total. Baseline mortality rates are presented in Table 5-7.

Table 5-16: Guillemot estimated displacement mortalities to be modelled under PVA

Impact scenario	Displacement / mortality rates	Displacement mortality estimates		
		Breeding	Non-breeding	Annual total
1	40% / 1%	22	3	25
2	60% / 1%	32	5	37
3	40% / 3%	64	9	73

Impact scenario	Displacement / mortality rates	Displacement mortality estimates		
		Breeding	Non-breeding	Annual total
4	60% / 3%	96	14	110
5	40% / 5%	106	15	121
6	60% / 5%	159	23	182
7	40% / 10%	212	30	242
8	60% / 10%	317	45	362

Table 5-17: Razorbill estimated displacement mortalities to be modelled under PVA

Impact scenario	Displacement / mortality rates	Displacement mortality estimates				
		Breeding	Autumn migration	Non-breeding	Spring migration	Annual total
1	40% / 1%	1	1	1	1	4
2	60% / 1%	2	1	1	1	5
3	40% / 3%	3	1	1	1	6
4	60% / 3%	4	1	1	1	7
5	40% / 5%	4	1	1	1	7
6	60% / 5%	6	1	1	1	9
7	40% / 10%	7	2	1	1	11
8	60% / 10%	11	2	1	2	16

Table 5-18: Puffin estimated displacement mortalities to be modelled under PVA

Impact scenario	Displacement / mortality rates	Displacement mortality estimates		
		Breeding	Non-breeding	Annual total
1	40% / 1%	6	1	7
2	60% / 1%	9	1	10
3	40% / 3%	17	1	18
4	60% / 3%	26	1	27
5	40% / 5%	29	1	30

Impact scenario	Displacement / mortality rates	Displacement mortality estimates		
		Breeding	Non-breeding	Annual total
6	60% / 5%	43	1	44
7	40% / 10%	57	1	58
8	60% / 10%	85	1	86

PVA reference populations

5.3.4.4 The reference populations used for each species in the PVA modelling are presented in Table 5-19. They are the same populations as referenced in the submitted ES and, in respect of guillemot, for which PVA was previously undertaken. More recent counts for guillemot and for razorbill were undertaken in 2021 but have not been used in the modelling. They are included in Table 5-19 for reference.

5.3.4.5 While these most recent counts have not been directly input into the PVA modelling, they can be used to sense-check the work, and inform the selection of most appropriate demographic parameters out of the available options. Please see the discussion in the following section.

Table 5-19: Reference populations for each auk species at SSSoP

Species	SPA	Population used in PVA		Most recent counts	
		Breeding individuals	Year(s) of census	Breeding individuals	Year(s) of census
Guillemot	Skomer, Skokholm and the Seas off Pembrokeshire	29,744	2017-2019	32,122	2021
Razorbill		10,694	2018-2019	11,524	2021
Puffin		38,342	2018		

PVA model options

5.3.4.6 There were a number of available options for the auk PVA modelling. As well as the national default rates, the NE PVA tool also includes specific survival rates calculated for Skomer (for adult and immature age-classes; means and standard deviations) based on available data.

5.3.4.7 Specific productivity rates are also included in the NE PVA tool for Skomer, determined from breeding success data collected under the Seabird Monitoring Programme (1985-2011). While it also includes default productivity rates for Skokholm, no overall SPA rate is provided, so the Skomer rates have been used in preference, as this island is the one which supports the highest numbers of each species in the SPA.

5.3.4.8 In this regard, PVAs were run using both the national default and Skomer options in the NE PVA tool, and the outputs compared and sense-checked against the recorded population trends at the SPA, including the most recent counts noted in Table 5-19.

5.3.4.9 A further PVA was also run for guillemot, using the adult survival rate determined by Birkhead (2021) (as discussed in relation to the original modelling presented in Volume 3, Technical Appendix 11.5: Population Modelling), and the Skomer option in the NE PVA tool for all the other demographic parameters.

5.3.4.10 Each of these PVA model options was sense-checked against the observed population trends for each of the auk species at Skomer, Skokholm and Seas off Pembrokeshire SPA, before a final choice was made on which to adopt for assessment.

PVA sense-check and choice of model option

5.3.4.11 The different PVA options were reviewed and the predicted population trends sense-checked against the available SPA counts and observed trends over time.

5.3.4.12 For guillemot, the SPA population has effectively doubled over the past twenty years, from 15,262 birds in 2000, to 24,328 in 2013, to 29,744 in 2019, and 32,122 in 2021. While the three modelled PVAs for guillemot all predicted an increasing population trend it was the option using Skomer values from the NE PVA tool (including adult survival) that most closely matched the observed trend. The option using the national defaults appeared to over-estimate potential population growth, while the option using the Birkhead (2021) adult survival rate under-estimated it.

5.3.4.13 In respect of the increasing guillemot population, note that density dependence was not modelled for any of the species due to a lack of available data. However, it is still possible to investigate and interpret the significance of modelled impacts using density independent models.

5.3.4.14 For razorbill, the SPA population has also been increasing since the Seabird 2000 count where 5,405 birds were recorded, to 8,957 birds in 2013, 10,694 in 2019, and 11,524 in 2021. Neither PVA option (either using national default values or using Skomer values) reflected this observed trend; both predicted a declining population. However, the rate of decline was less steep when using the national defaults (a predicted baseline population of 7,377 birds in 2053, as opposed to 3,769 using Skomer values) and so this was the option selected for reference.

5.3.4.15 For puffin, observed trends were the same, with an increasing population at the SPA from 12,717 birds recorded during Seabird 2000, to the most recent count of 38,342 birds in 2018. Again, neither PVA option (national defaults or Skomer values) reflected this trend, both predicted a declining population. In this instance it was the option using Skomer values that gave a less steep rate of decline (a baseline population of 28,040 birds in 2053, compared with 18,217 using the national defaults) and so this has been selected for reference.

5.3.4.16 Despite this divergence between observed and predicted population trends for razorbill and puffin, the PVAs are still effective in determining the likely population consequences of potential mortalities arising (the modelled impact scenarios for each species). Please see further discussion under 'Auk PVA Outputs', Section 5.3.4.28 below.

5.3.4.17 Also, when the model outputs for each species from each PVA option were compared (the 'counterfactuals' as discussed under 'Auk PVA Outputs', Section 5.3.4.28 below) there were negligible differences between them. So, in this regard, the assessment outcome – the comparison of impacted scenarios against the baseline – appears to be robust, no matter the final PVA option chosen (and indeed appears to be robust because of this convergence in PVA results).

Demographic parameters

5.3.4.18 Table 5-20 summarises the demographic parameters used in the submitted PVAs.

Table 5-20: Summary of demographic rates for PVA species (Guillemot and puffin use Skomer values and razorbill the national defaults, as recorded in the NE PVA tool)

Demographic rates	Guillemot		Razorbill		Puffin	
	Mean	SD	Mean	SD	Mean	SD
Adult survival	0.930	0.043	0.895	0.067	0.906	0.047
Productivity (per pair)	0.687	0.078	0.642	0.271	0.754	0.070
Age of recruitment	6	-	5	-	5	-
Brood size (per pair)[1]	1	-	1	-	1	-
Survival 0 → 1	0.560	0.058	0.63	0.209	0.709	0.108
Survival 1 → 2	0.762	0.152	0.63	0.209	0.709	0.108
Survival 2 → 3	0.917	0.098	0.895	0.064	0.709	0.108
Survival 3 → 4	0.938	0.107	0.895	0.064	0.76	0.093
Survival 4 → 5	0.930	0.043	0.895	0.064	0.805	0.083
Survival 5 → 6	0.930	0.043	-	-	-	-

1. Mean brood size (per pair) values taken from Snow and Perrins (1998).

Age-classes

5.3.4.19 The NE PVA tool allows the user to choose whether to use the same survival rate across all age groups, or to use age-dependent survival rates. For all the modelling undertaken, the Skomer age-dependent survival rates were used (as provided in the NE PVA tool).

5.3.4.20 The displacement mortality estimates to be modelled were split, proportionally, by adult and immature age-classes. The proportions were obtained by using the "*burn in*" function of the PVA tool, to obtain a stable age structure for the population of each species at the start of the model period.

5.3.4.21 These proportions are presented in Table 5-21 and then applied to the total displacement mortality estimates, to give the numbers of adults and immatures as presented for each impact scenario in Table 5-22 to Table 5-24.

Table 5-21: Age-class proportions determined for each auk species at SSSoP

Species	Proportion of adults	Proportion of immatures
Guillemot	0.49	0.51
Razorbill	0.60	0.40
Puffin	0.48	0.52

Model duration

5.3.4.22 The PVA models were run from 2018 or 2019 (the end year of the SPA population censuses) and impacts were modelled to commence in 2028, based on an assumed commissioning date of October 2027, and to last for 25 years (the assumed lifetime of the wind farm). The end of the modelled period is therefore 2053.

5.3.4.23 For each species, each simulation was run 1,000 times to obtain a projected population trajectory and associated uncertainty due to environmental and demographic stochasticity. Although 5,000 bootstrap samples is the default for the online ‘R Shiny’ tool, a sense check of scenarios found that the difference between 1,000 and 5,000 bootstraps was negligible. In several cases, the counterfactuals were the same regardless of how many simulations were run. This can be examined by selecting one of the case studies built into the ‘R Shiny’ tool, and setting the number of simulations and the random seed appropriately.

Impact scenarios

5.3.4.24 The impact scenarios modelled under PVA are presented in Table 5-22 to Table 5-24, based on the range of annual displacement mortality estimates for each species, as calculated in Table 5-16 to

5.3.4.25 Table 5-18, with numbers of adults and immatures derived from the age-class proportions presented in Table 5-21.

5.3.4.26 For each impact scenario, relative rates of mortality are applied separately in the PVA modelling for adults and immatures. All scenarios were tested, despite many being below the 1% baseline mortality threshold. These relative rates of mortality are calculated from the absolute mortality estimates (adults and immatures), as a proportion of the respective adult and immature populations in the year for which impacts are modelled to commence (i.e., 2028). These relative rates of mortality are presented in Table 5-22 to Table 5-24.

5.3.4.27 The SNCBs (and the NE PVA model guidance) recommend the use of relative rates of mortality when modelling offshore wind farm impacts, as they scale the impact according to the total population size in each year. It should be noted that other projects did not apportion any mortality to these populations, and CRM impacts are zero/negligible. As such, the PVA undertaken here is considered to be inclusive of displacement effects, collision risk, and inclusive of all other projects included in the CEA (where data are available).

Table 5-22: Modelled impact scenarios for guillemot

Scenario	Impacts modelled *(annual impacts from displacement)*	Absolute mortalities[1]			Relative mortality rates[2]	
		Total	Adults	Immatures	Adults	Immatures
1	40% displacement rate / 1% mortality rate	25	12.25	12.75	0.33×10^{-3}	0.33×10^{-3}
2	60% displacement rate / 1% mortality rate	37	18.13	18.87	0.48×10^{-3}	0.48×10^{-3}
3	40% displacement rate / 3% mortality rate	73	35.77	37.23	0.95×10^{-3}	0.95×10^{-3}
4	60% displacement rate / 3% mortality rate	110	53.9	56.1	1.43×10^{-3}	1.43×10^{-3}
5	40% displacement rate / 5% mortality rate	121	59.29	61.71	1.58×10^{-3}	1.58×10^{-3}
6	60% displacement rate / 5% mortality rate	182	89.18	92.82	2.37×10^{-3}	2.37×10^{-3}
7	40% displacement rate / 10% mortality rate	242	118.58	123.42	3.15×10^{-3}	3.15×10^{-3}
8	60% displacement rate / 10% mortality rate	362	177.38	184.62	4.72×10^{-3}	4.72×10^{-3}

[1]Absolute mortalities = estimated annual number of bird mortalities.

[2]Relative mortality rates = absolute mortalities as a proportion of the 2027 baseline.

Table 5-23: Modelled impact scenarios for razorbill

Scenario	Impacts modelled *(annual impacts from displacement)*	Absolute mortalities[1]			Relative mortality rates[2]	
		Total	Adults	Immatures	Adults	Immatures
1	40% displacement rate / 1% mortality rate	4	2.4	1.6	0.30×10^{-3}	0.30×10^{-3}
2	60% displacement rate / 1% mortality rate	5	3	2	0.37×10^{-3}	0.37×10^{-3}
3	40% displacement rate / 3% mortality rate	6	3.6	2.4	0.45×10^{-3}	0.45×10^{-3}
4	60% displacement rate / 3% mortality rate	7	4.2	2.8	0.52×10^{-3}	0.52×10^{-3}
5	40% displacement rate / 5% mortality rate	7	4.2	2.8	0.52×10^{-3}	0.52×10^{-3}
6	60% displacement rate / 5% mortality rate	9	5.4	3.6	0.67×10^{-3}	0.67×10^{-3}
7	40% displacement rate / 10% mortality rate	11	6.6	4.4	0.74×10^{-3}	0.74×10^{-3}
8	60% displacement rate / 10% mortality rate	16	9.6	6.4	1.19×10^{-3}	1.19×10^{-3}

[1] *Absolute mortalities = estimated annual number of bird mortalities.*

[2] *Relative mortality rates = absolute mortalities as a proportion of the 2027 baseline.*

Table 5-24: Modelled impact scenarios for puffin

Scenario	Impacts modelled *(annual impacts from displacement)*	Absolute mortalities[1]			Relative mortality rates[2]	
		Total	Adults	Immatures	Adults	Immatures
1	40% displacement rate / 1% mortality rate	7	3.36	3.64	0.09×10^{-3}	0.09×10^{-3}
2	60% displacement rate / 1% mortality rate	10	4.8	5.2	0.14×10^{-3}	0.14×10^{-3}
3	40% displacement rate / 3% mortality rate	18	8.64	9.36	0.24×10^{-3}	0.24×10^{-3}
4	60% displacement rate / 3% mortality rate	27	12.96	14.04	0.37×10^{-3}	0.37×10^{-3}
5	40% displacement rate / 5% mortality rate	30	14.4	15.6	0.41×10^{-3}	0.41×10^{-3}
6	60% displacement rate / 5% mortality rate	44	21.12	22.88	0.60×10^{-3}	0.60×10^{-3}
7	40% displacement rate / 10% mortality rate	58	27.84	30.16	0.79×10^{-3}	0.79×10^{-3}
8	60% displacement rate / 10% mortality rate	86	41.28	44.72	1.17×10^{-3}	1.17×10^{-3}

[1]*Absolute mortalities = estimated annual number of bird mortalities.*

[2]*Relative mortality rates = absolute mortalities as a proportion of the 2027 baseline.*

Auk PVA outputs

5.3.4.28 The key outputs from the PVA tool are the counterfactuals of population growth rate and of population size (Searle *et al.,* 2019). These are the ratios of the impacted to unimpacted (baseline) scenarios, and allow meaningful interpretation of the predicted effects against the populations in question (Cook and Robinson, 2016). Developing guidance from the SNCBs, including NRW and JNCC, indicates that these are the metrics that will be used in making judgements on the viability of protected seabird populations.

5.3.4.29 Testing the sensitivities of these metrics has suggested that counterfactual of growth rate is useful to illustrate impacts, regardless of population status or trend (Cook and Robinson, 2016). Cook and Robinson (2016) also found the counterfactual of population size can be used to assess the population level effects of impacts for stable or increasing populations, and may also offer a useful context for the counterfactual of growth rate.

5.3.4.30 Model outputs are presented in Table 5-25 for guillemot, Table 5-26 for razorbill and Table 5-27 for puffin.

Interpretation of auk PVA outputs and conclusions

5.3.4.31 The population modelling gives confidence that the Project will not lead to adverse impacts on the viability of the breeding auk populations at Skomer, Skokholm and Seas off Pembrokeshire SPA.

5.3.4.32 For razorbill, the maximum reduction in growth rate is 0.1%, and the end population size is reduced by 2.7% for the 60% displacement rate and 10% mortality rate. For puffin, the reductions are 0.1% and 3.7%, respectively; based on a 60% displacement rate and 10% mortality rate. For guillemot, at a 60% displacement rate and 10% mortality rate, the maximum reduction in growth rate is 0.5% and the end population size is reduced by 13%.These estimates represent the upper bounds of what NRW Advisory and JNCC perceive to be potential impacts, but the application of the same rates across seasons and across the array area and buffer has not been justified.

5.3.4.33 The level of displacement mortality in this scenario (e.g. 362 guillemot) is clearly an overestimate, given that the MSPs have been estimated based on the whole outline array area and 2 km buffer; the buffer is a third larger than the array alone and the same displacement and mortality rates have been applied over the entire area. Decisions need to be based on a more realistic option, accounting for the reduction in maximum number of turbines (now the 9.5MW turbines are removed from the design envelope) as well as the likely reduction in any array area to be built out.

5.3.4.34 Therefore, the auk displacement reassessment confirms that there will be **no adverse effect on site integrity** arising from the Project on either guillemot, razorbill or puffin as qualifying interests of Skomer, Skokholm and Seas off Pembrokeshire SPA.

5.3.4.35 For guillemot, the modelled baseline population increased between the census years (2017-2019) and the commencement of impacts (2028), from 29,744 adult birds to 37,906. After this point, the impact scenario populations increased at a slower rate than baseline population. Table 5-25 presents the differences in growth rate (increasing population in this case) at the end of the 25 years of impact (2053) as estimated by the PVA tool. The difference in median population size ranged from 1% (Scenario 1) to 13% (Scenario 8).

Table 5-25: Metrics and counterfactuals (with 95% Confidence Intervals (CI)) for 1,000 simulations of the guillemot PVA

Guillemot scenarios	Mortality - relative rate		Median pop. size at end of modelled period (adult IND)	Median counterfactuals	
	Adult	Immature		CGR (95% CIs)	CPS (95% CIs)
1 - 40% displacement rate / 1% mortality rate	0.33×10^{-3}	0.33×10^{-3}	75,566	1.000 *(0.999-1.000)*	0.990 *(0.972-1.008)*
2- 60% displacement rate / 1% mortality rate	0.48×10^{-3}	0.48×10^{-3}	74,719	0.999 *(0.999-1.000)*	0.986 *(0.968-1.005)*
3 - 40% displacement rate / 3% mortality rate	0.95×10^{-3}	0.95×10^{-3}	74,730	0.999 *(0.998-1.000)*	0.972 *(0.954-0.990)*
4 - 60% displacement rate / 3% mortality rate	1.43×10^{-3}	1.43×10^{-3}	73,387	0.998 *(0.998-0.999)*	0.959 *(0.939-0.977)*
5 - 40% displacement rate / 5% mortality rate	1.58×10^{-3}	1.58×10^{-3}	72,369	0.998 *(0.998-0.999)*	0.955 *(0.938-0.972)*
6 - 60% displacement rate / 5% mortality rate	2.37×10^{-3}	2.37×10^{-3}	72,239	0.997 *(0.997-0.998)*	0.933 *(0.915-0.949)*
7 - 40% displacement rate / 10% mortality rate	3.15×10^{-3}	3.15×10^{-3}	70,541	0.996 *(0.996-0.997)*	0.911 *(0.895-0.929)*
8 - 60% displacement rate / 10% mortality rate	4.72×10^{-3}	4.72×10^{-3}	68,973	0.995 *(0.994-0.995)*	0.870 *(0.854-0.887)*

IND = Individuals. *CGR = Counterfactual Growth Rate.* *CPS = Counterfactual Population Size.*

5.3.4.36 For razorbill, the modelled baseline population decreased between the census years (2017-2019) and the commencement of impacts (2028), falling from 10,694 adult birds to 8,117. After this point, the baseline population decreased at a lesser rate than all the impact scenario populations. Table 5-26 presents the differences in growth rate at the end of the 25 years of impact (2053) as estimated by the PVA tool. The difference in median population size ranged from 0.9% (Scenario 1) to 3.5% (Scenario 8).

Table 5-26: Metrics and counterfactuals (with 95% Confidence Intervals (CI)) for 1,000 simulations of the razorbill PVA

Razorbill scenarios	Mortality - relative rate		Median pop. size at end of modelled period (adult IND)	Median counterfactuals	
	Adult	Immature		CGR (95% CIs)	CPS (95% CIs)
1 - 40% displacement rate / 1% mortality rate	0.30×10^{-3}	0.30×10^{-3}	7,377	1.000 *(0.998-1.001)*	0.993 *(0.942-1.045)*
2- 60% displacement rate / 1% mortality rate	0.37×10^{-3}	0.37×10^{-3}	7,349	1.000 *(0.998-1.001)*	0.992 *(0.939-1.049)*
3 - 40% displacement rate / 3% mortality rate	0.45×10^{-3}	0.45×10^{-3}	7,339	1.000 *(0.998-1.001)*	0.991 *(0.940-1.042)*
4 - 60% displacement rate / 3% mortality rate	0.52×10^{-3}	0.52×10^{-3}	7,302	1.000 *(0.998-1.001)*	0.988 *(0.937-1.039)*
5 - 40% displacement rate / 5% mortality rate	0.52×10^{-3}	0.52×10^{-3}	7,305	1.000 *(0.998-1.001)*	0.989 *(0.937-1.044)*
6 - 60% displacement rate / 5% mortality rate	0.67×10^{-3}	0.67×10^{-3}	7,303	0.999 *(0.998-1.001)*	0.985 *(0.934-1.038)*
7 - 40% displacement rate / 10% mortality rate	0.74×10^{-3}	0.74×10^{-3}	7,315	0.999 *(0.997-1.001)*	0.983 *(0.933-1.037)*
8 - 60% displacement rate / 10% mortality rate	1.19×10^{-3}	1.19×10^{-3}	7,280	0.999 *(0.997-1.001)*	0.973 *(0.923-1.027)*

IND = Individuals. *CGR = Counterfactual Growth Rate.* *CPS = Counterfactual Population Size.*

5.3.4.37 For puffin, the modelled baseline population decreased between the census year (2018) and the commencement of impacts (2028), from 38,342 adult birds to 35,216. After this point, the baseline population decreased slightly less than all the impact scenario populations. Table 5-27 presents the differences in growth rate at the end of the 25 years of impact (2053) as estimated by the PVA tool. the difference in median population size was 0.4% for Scenario 1 and to 3.7% for Scenario 8.

Table 5-27: Metrics and counterfactuals (with 95% Confidence Intervals (CI)) for 1,000 simulations of the puffin PVA

Puffin scenarios	**Mortali–y - relative rate**		**Median pop. size at end of modelled period (adult IND)**	**Median counterfactuals**	
–1 - 40% displacement rate / 1% mortality rate	0.09×10^{-3}	0.09×10^{-3}	28,040	1.000 *(0.999-1.001)*	0.996 *(0.968-1.024)*
–8 - 60% displacement rate / 10% mortality rate	1.17×10^{-3}	1.17×10^{-3}	27,349	0.999 *(0.998-1.000)*	0.963 *(0.937-0.989)*

IND = Individuals. *CGR = Counterfactual Growth Rate.* *CPS = Counterfactual Population Size.*

5.4 Reassessment - Gannet

5.4.1.1 Non-ID apportioning is not an issue for gannet, as individuals are readily identifiable and always recorded to species level. However, further to the 28 June 2022 meeting and discussion there, it has been decided to recalculate the gannet mortality estimates, taking account of NRW Advisory and JNCC advice on collision risk modelling and displacement assessment, as presented in Section 5.1 and 5.2 of this SEI report.

5.4.1.2 In this regard, it is confirmed that the recalculated mortalities for The Project, as apportioned to Grassholm SPA, in combination with the available estimates for other developments (also apportioned to Grassholm), does not lead to a cumulative gannet mortality estimate greater than the worst case (99 birds) previously modelled under PVA (ES Volume 3, Technical Appendix 11.5: Population Modelling). Calculation of the cumulative gannet mortality estimate is presented in Section 5.4.4.

5.4.1.3 Therefore, PVA modelling has not been redone. Also, the recalculated estimates lie just below the identified 1% threshold of significance used to determine whether a PVA is required (Appendix A - Offshore Ornithology of this SEI report).

5.4.2 Gannet collision risk modelling

5.4.2.1 The details of methods and approach to collision risk modelling (CRM) are set out in ES Volume 3, Technical Appendix 11.3: Collision Risk Modelling, and this information is not repeated here.

5.4.2.2 As advised by NRW Advisory and JNCC, collision risk has been remodelled for gannet, applying a 70% reduction to input densities (i.e., 30% of the original density estimates) as set out in Table 5-29 to Table 5-31. This recommended reduction accounts for the levels of gannet displacement (macro-avoidance) being recorded at operational offshore wind farms, and means that assessment does not double-count estimated collision and displacement impacts.

5.4.2.3 NRW Advisory and JNCC recommendations on gannet CRM input parameters have also been followed, including application of a nocturnal activity factor; use of a 'default' flight speed (14.9 m/s), as well as that (13.1 m/s) calculated in Langley and Votier (2021); and use of 'gliding' rather than 'flapping' flight. These updated input parameters are presented in Table 5-28.

Table 5-28: Gannet biometric and behavioural input parameters

Body length (m)	Wingspan (m)	Flight speed (m/sec)	Nocturnal activity	Flight type
0.935	1.73	13.1 and 14.9	0.18	Gliding

5.4.2.4 As noted, the 9.5 MW ten-turbine scenario has now been removed from the design envelope; the 14 MW seven-turbine scenario is now remodelled as 'worst case', and only CRM option 2 mortality estimates are presented for this reassessment. In this regard, the values for each turbine parameter, and for the monthly estimates of operational downtime, remain the same as those presented in ES Volume 3, Technical Appendix 11.3: Collision Risk Modelling (Tables 1 and 2).

5.4.2.5 As set out in the 'Ornithology Consultation Clarification Technical Note', use of option 2 substantially reduces the number of predicted collisions (for all species including gannet), compared with option 1, previously taken forward for assessment as 'worst case'.

Table 5-29: Gannet monthly mean input flying bird densities

Monthly densities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.05	0.66	0.79	1.28	1.22	1.32	0.44	1.95	0.95	0.27	0.09	0.05
SD	0.09	0.37	0.37	0.60	0.68	0.81	0.37	1.84	0.70	0.13	0.11	0.09
30% densities	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mean	0.01	0.20	0.24	0.38	0.37	0.40	0.13	0.59	0.29	0.08	0.03	0.01
SD	0.03	0.11	0.11	0.18	0.21	0.24	0.11	0.55	0.21	0.04	0.03	0.03

Table 5-30: Gannet CRM model option 2 mortality estimates at 30% densities

Monthly mortalities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
13.1 m/s flight speed												
Mean	0.05	0.33	0.46	0.82	0.94	1.04	0.38	1.64	0.66	0.15	0.06	0.04
SD	0.04	0.23	0.29	0.51	0.61	0.69	0.29	1.29	0.49	0.1	0.05	0.04
14.9 m/s flight speed												
Mean	0.05	0.35	0.49	0.87	1	1.11	0.41	1.75	0.7	0.16	0.07	0.04
SD	0.04	0.24	0.3	0.55	0.65	0.73	0.31	1.38	0.52	0.1	0.05	0.04

Table 5-31: Gannet seasonal collision mortalities, option 2 at 30% densities

Flight speed	Gannet collision mortalities	Breeding season	BDMPS			Annual total
			autumn migration	non-breeding	spring migration	
		Apr - Aug	Sep - Nov	n/a	Dec - Mar	
13.1 m/s	Seasonal mortality	4.82	0.87	n/a	0.87	6.56
	SD	2.41	0.55	n/a	0.46	n/a
14.9 m/s	Seasonal mortality	5.15	0.93	n/a	0.93	7.01
	SD	2.58	0.59	n/a	0.50	n/a

5.4.3 Gannet displacement assessment

5.4.3.1 The details of SNCB (2017) guidance and approach to displacement assessment are set out in ES Volume 3, Technical Appendix 11.4: Displacement Analysis, and are not repeated here.

5.4.3.2 As requested in terms of presentation, the displacement matrices for gannet have been updated to apportion the breeding and non-breeding MSPs to Grassholm SPA, using the agreed apportioning weightings set out in Appendix A - Offshore Ornithology of this SEI report. The new matrices are presented in Table 5-32 to Table 5-34.

5.4.3.3 'Worst case' displacement mortality estimates for gannet are based on NRW Advisory and JNCC advice, to use a 70% displacement rate and a 10% mortality rate, applied uniformly across breeding and non-breeding seasons.

5.4.3.4 These 'worst case' gannet mortality estimates, as apportioned to Grassholm SPA, are as follows:

- Breeding season: 16 birds;
- Autumn migration: 4 birds;
- Spring migration: 1 bird; and
- Annual total: 21 birds.

5.4.4 Consideration of project-alone and cumulative gannet impacts

5.4.4.1 The predicted gannet collision mortalities presented in Table 5-30 are apportioned to Grassholm SPA as follows, noting that the CRM outputs at the 14.9 m/s flight speed are used to inform assessment, being slightly higher than those at the 13.1 m/s flight speed. An SPA apportioning weighting of 0.995 is used for the breeding season; 0.144 for autumn migration and 0.119 for spring migration (see Appendix A - Offshore Ornithology of this SEI report).

- Breeding season: 5.15 x 0.995 = 5.12 birds;
- Autumn migration: 0.93 x 0.144 = 0.13 birds;
- Spring migration: 0.93 x 0.119 = 0.11 birds; and
- Annual total: 5.36 birds, rounded up to nearest whole bird = 6 birds.

5.4.4.2 Other developments potentially affecting the gannet population at Grassholm SPA are discussed under 'Cumulative Impacts' in Section 5.2.5. There are an estimated four gannet mortalities from Awel y Môr apportioned to Grassholm SPA, and the single gannet mortality arising from Morlais has also been included here on a precautionary basis. All other Tier 1 projects either have no impacts on gannet at Grassholm SPA, or else have not quantified them. Therefore, the total gannet mortalities apportioned to the SPA are as follows:

- 21 + 6 + 4 + 1 = 32 birds

5.4.4.3 This cumulative total lies below the threshold (1% baseline mortality) for considering PVA, a figure of 58 birds (Appendix A - Offshore Ornithology of this SEI report). Not only this, but the 'worst case' previously modelled (99 mortalities) was shown not to impact on the viability of the SPA gannet population. Therefore, there will be no **adverse effect on site integrity** at Grassholm SPA arising from The Project, either alone or in-combination with other Tier 1 projects.

Table 5-32: Gannet estimated breeding season displacement mortality, as apportioned to Grassholm SPA

Gannet Apr - Aug		Mortality Level (% of displaced birds that die)												
		0%	**1%**	**2%**	**3%**	**4%**	**5%**	**10%**	**15%**	**20%**	**30%**	**50%**	**80%**	**100%**
Displacement Level (% of all birds on-site)	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	1	1	1	1	2	3	4	5	7	12	18	23
	20%	0	1	1	2	2	3	5	7	9	14	23	36	45
	30%	0	1	2	3	3	4	7	11	14	21	34	54	67
	40%	0	1	2	3	4	5	9	14	18	27	45	72	90
	50%	0	2	3	4	5	6	12	17	23	34	56	90	112
	60%	0	2	3	5	6	7	14	21	27	41	67	107	134
	70%	0	2	4	5	7	8	16	24	32	47	79	125	157
	80%	0	2	4	6	8	9	18	27	36	54	90	143	179
	90%	0	3	5	7	9	11	21	31	41	61	101	161	201
	100%	0	3	5	7	9	12	23	34	45	67	112	179	223

Table 5-33: Gannet estimated autumn migration displacement mortality, as apportioned to Grassholm SPA

Gannet Sep - Nov		Mortality Level (% of displaced birds that die)												
		0%	1%	2%	3%	4%	5%	10%	15%	20%	30%	50%	80%	100%
Displacement Level (% of all birds on-site)	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	1	1	1	1	1	1	1	1	2	3	4	5
	20%	0	1	1	1	1	1	1	2	2	3	5	8	10
	30%	0	1	1	1	1	1	2	3	3	5	8	12	15
	40%	0	1	1	1	1	1	2	3	4	6	10	16	20
	50%	0	1	1	1	1	2	3	4	5	8	13	20	25
	60%	0	1	1	1	2	2	3	5	6	9	15	24	29
	70%	0	1	1	2	2	2	4	6	7	11	17	27	34
	80%	0	1	1	2	2	2	4	6	8	12	20	31	39
	90%	0	1	1	2	2	3	5	7	9	13	22	35	44
	100%	0	1	1	2	2	3	5	8	10	15	25	39	49

Table 5-34: Gannet estimated autumn migration displacement mortality, as apportioned to Grassholm SPA

Gannet Dec - Mar		Mortality Level (% of displaced birds that die)												
		0%	1%	2%	3%	4%	5%	10%	15%	20%	30%	50%	80%	100%
Displacement Level (% of all birds on-site)	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	10%	0	1	1	1	1	1	1	1	1	1	1	1	2
	20%	0	1	1	1	1	1	1	1	1	1	2	2	3
	30%	0	1	1	1	1	1	1	1	1	2	2	3	4
	40%	0	1	1	1	1	1	1	1	1	2	3	4	5
	50%	0	1	1	1	1	1	1	1	2	2	3	5	6
	60%	0	1	1	1	1	1	1	2	2	3	4	6	8
	70%	0	1	1	1	1	1	1	2	2	3	5	7	9
	80%	0	1	1	1	1	1	1	2	2	3	5	8	10
	90%	0	1	1	1	1	1	2	2	3	4	6	9	11
	100%	0	1	1	1	1	1	2	2	3	4	6	10	12

5.5 Cumulative Effects Assessment

5.5.1 Inclusion of Hexicon (Wave Hub) in the Offshore Ornithology CEA

5.5.1.1 NRW Advisory commented on the CEA for ornithology stating that "*…the Applicant also needs to consider the wave hub bought by Hexicon off the Cornish coast…*" specifically mentioning this should be included in the assessment for northern gannet, but also a general request for inclusion of the Project in the CEA.

5.5.1.2 The following text is therefore in response to, and applicable to, the following comments from consultees:

- NRW Advisory Technical Experts (Row 279): Pg 92; Table 11.36: The Applicant needs to include the Wave Hub site bought by Hexicon off the Cornish coast in a cumulative effect assessment;
- NRW Advisory Technical Experts (Row 351): In terms of cumulative assessment, the Applicant also needs to consider the wave hub bought by Hexicon off the Cornish coast in the cumulative impact HRA for gannet (**note:** refer to Section 8 of this SEI Addendum for updates to the HRA CIA); and
- NRW Advisory Technical Experts (Row 371): The Applicant needs to consider the wave hub bought by Hexicon off the Cornish coast in the cumulative impact HRA.

5.5.1.3 The original ES for the Wave Hub Project was produced in 2006, when the Project was proposed to comprise an offshore wave energy test site off the Cornish coast. However, the site has recently changed ownership. Since the change in ownership, the Project design has been updated, an updated ES has been produced (Xodus, 2018), detailing the new Project design and assessment of effects. It is now proposed that the site is used for FLOW. The assessment included collision risk to offshore ornithological receptors. A summary of the results of the Wave Hub assessment are presented in Table 5-35.

Table 5-35: Summary of Wave Hub collision risk assessment (Source: Xodus, 2018)

Common Name	Latin Name	Collision Risk Mortality	Wave Hub Assessment Determination
Northern gannet	*Morus bassanus*	39.9	Negligible (not significant)
Herring gull	*Larus argentatus*	22.9	Negligible (not significant)
Great black-backed gull	*Larus marinus*	12.3	Negligible (not significant)
Lesser black-backed gull	*Larus fuscus*	5.9	Negligible (not significant)
Black-legged kittiwake	*Rissa tridactyla*	10.8	Negligible (not significant)

5.5.1.4 Table 5-36 presents the updated collision risk CEA for The Project, including the Projects originally included in the ES, as well as the collision risk mortalities identified in the Wave Hub ES. The northern gannet mortality rate presented in Table 5-36 has been updated to reflect reassessment of northern gannet following agreement with NRW Advisory and JNCC that the input density is reduced by 70% to account for macroavoidance observed at operational OWFs.

Table 5-36: Updated summary of collision risk mortalities associated with The Project and other Projects screened into the offshore ornithology cumulative effects assessment (n.d. = no data)

Project	Northern Gannet	Herring Gull	Great Black-backed Gull	Lesser Black-backed Gull	Black-legged Kittiwake
Erebus	21	3	1	6	58
Burbo Bank Extension	11	14	n.d.	26	21
Walney 1 and 2	n.d.	n.d.	n.d.	58	n.d.
Walney Extension	38	55	29	13	188
West of Duddon Sands	n.d.	n.d.	n.d.	45	n.d.
Wave Hub	40	23	13	6	11
Total	**110**	**95**	**43**	**154**	**278**

5.5.1.5 The following sections provide updated collision risk CEAs for the species included in the Wave Hub ES, as requested by NRW Advisory Technical Experts in comments on the Project ES.

Northern Gannet Collision Risk CEA

5.5.1.6 The updated cumulative predicted collision risk mortality for northern gannet, in Projects for which quantified values are available, is presented in Table 5-36. A mortality rate of 110 individuals represents 0.02% of the BDMPS population of 545,954 individuals September to November, 0.02% of the BDMPS population of 661,888 individuals December to March (Furness, 2015), and 0.28% of the migration free breeding season population of 72,022 individuals (Pritchard *et al.*, 2021). However, it should be noted that these values assume that all mortalities occur in a single season. It is highly likely that mortalities will be split between seasons and, as such, the actual proportion or respective seasons affected will be smaller than those reported. Other Projects, where only qualitative assessments of collision risk on northern gannet are available, assess the risk to the species as very low or negligible.

5.5.1.7 Therefore, it is determined that the overall cumulative collision risk effect of the Project, along with the other projects scoped in for CEA, on northern gannet is **minor adverse** effect, which is not significant in EIA terms.

Herring Gull Collision Risk CEA

5.5.1.8 The updated cumulative predicted collision risk mortality for herring gull, in projects for which quantified values are available, is presented in Table 5-36. A mortality rate of 95 individuals represents 0.05% of the BDMPS population of 173,299 individuals September to February (Furness, 2015).

5.5.1.9 The apportioning analysis for the Walney Extension OWF (NIRAS, 2013a) indicates that the only colony at risk of collision effects is the Morecambe Bay population. This colony is located at least 300 km (at-sea) from the Project, putting it outside the foraging range of herring gull (Woodward *et al*., 2019). Therefore, there is no pathway for cumulative effects on breeding populations from the Project in addition to Walney Extension.

5.5.1.10 Burbo Bank Extension OWF is located to the south of Walney Extension OWF, within Liverpool Bay, and although apportioning assessment results are not available for this project, it is considered likely that this will predominantly affect local populations of herring gull. Therefore, cumulative effects of the Project, in addition to Burbo Bank Extension on breeding colonies, are also considered very unlikely to occur.

5.5.1.11 It is noted that the ranges provided by Woodward *et al.* (2019) only account for foraging activities during the breeding season. However, given the small proportion of the relevant BDMPS predicted to be at risk, it is considered that this level of mortalities would result in negligible effects on the wider biogeographic population (with connectivity to UK waters) outside of the breeding season.

5.5.1.12 Other projects, where only qualitative assessments of collision risk on herring gull are available, assess the risk to the species as very low or negligible.

5.5.1.13 Therefore, it is determined that the overall cumulative collision risk effect of the Project, along with the other projects scoped in for CEA, on herring gull is **minor adverse** effect, which is not significant in EIA terms.

Great Black-backed Gull Collision Risk CEA

5.5.1.14 The updated cumulative predicted collision risk mortality for great black-backed gull, in projects for which quantified values are available, is presented in Table 5-36. A mortality rate of 30 individuals represents 0.24% of the BDMPS population of 17,742 individuals September to March (Furness, 2015). The other projects scoped in for CEA assess impacts to great black-backed gull from collision risk effects as minor or negligible, and monitoring reports for these projects show no impacts outside those predicted in the corresponding ES. Cumulatively, with the Project, mortality to the regional great black-backed gull population is not likely to be significant.

5.5.1.15 It is important to recognise that great black-backed gull has a foraging range of 73 km (SD not provided) (Woodward *et al.*, 2019) and that the Walney Extension OWF is located >300 km away from the Project array area. Therefore, there is very limited, to no, potential for the projects to interact with great black-backed gull from the same breeding colonies.

5.5.1.16 It is noted that the ranges provided by Woodward *et al.* (2019) only account for foraging activities during the breeding season. However, given the small proportion of the relevant BDMPS predicted to be at risk, it is considered that this level of mortalities would result in negligible effects on the wider biogeographic population (with connectivity to UK waters) outside of the breeding season

5.5.1.17 Therefore, it is determined that the overall cumulative collision risk effect of the Project, along with the other projects scoped in for CEA, on great black-backed gull is **minor adverse** effect, which is not significant in EIA terms.

Lesser Black-backed Gull Collision Risk CEA

5.5.1.18 The updated cumulative predicted collision risk mortality for lesser black-backed gull, in projects for which quantified values are available, is presented in Table 5-36. A mortality rate of 154 individuals represents 0.09% of the BDMPS population of 163,304 individuals August to October and March to April, and 0.37% of 41,159 individuals November to February (Furness, 2015). The other projects scoped in for CEA assess impacts to lesser black-backed gull from collision risk effects as minor or negligible, and monitoring reports for these projects show no impacts outside those predicted in the corresponding ES. Cumulatively, with the Project, mortality to the regional lesser black-backed gull population is not likely to be significant.

5.5.1.19 The apportioning analysis for the Project (ES Volume 3, Technical Appendix 11.2: Apportioning) suggests that 97.8% of lesser black-backed gull affected by the Project originate from the Skomer and Skokholm colony. This colony is located at least 275 km (at-sea distance) from both Walney and Burbo Bank OWFs, putting these projects outside the foraging range for the species (mean maximum foraging range (127 km) plus one standard deviation (109 km)) (Woodward *et al.*, 2019); therefore, there is very limited to no potential for these developments to affect the same lesser black-backed gull breeding season populations (DONG energy, 2013a-b).

5.5.1.20 It is noted that the ranges provided by Woodward *et al.* (2019) only account for foraging activities during the breeding season. However, given the small proportion of the relevant BDMPS predicted to be at risk, it is considered that this level of mortalities would result in negligible effects on the wider biogeographic population (with connectivity to UK waters) outside of the breeding season.

5.5.1.21 Other projects, where only qualitative assessments of collision risk on lesser black-backed gull are available, assess the risk to the species as very low or negligible.

5.5.1.22 Therefore, it is determined that the overall cumulative collision risk effect of the Project, along with the other projects scoped in for CEA, on lesser black-backed gull is **minor adverse** effect, which is not significant in EIA terms.

Black-legged Kittiwake Collision Risk CEA

5.5.1.23 The updated cumulative predicted collision risk mortality for black-legged kittiwake gull, in projects for which quantified values are available, is presented in Table 5-36. A mortality rate of 278 individuals represents 0.03% of the BDMPS population of 911,586 individuals August to December, and 0.04% of 691,526 individuals January to April (Furness, 2015). The other projects scoped in for CEA assess impacts to black-legged kittiwake from collision risk effects as minor or negligible, and monitoring reports for these projects show no impacts outside those predicted in the corresponding ES. Cumulatively, with the Project, mortality to the regional black-legged kittiwake population is not likely to be significant.

5.5.1.24 The apportioning analysis for the Project (ES Volume 3, Technical Appendix 11.2: Apportioning) suggests that 81.7% of black-legged kittiwake affected by the Project originate from the Skomer and Skokholm colony, 4.6% from Saltee Islands, 3.3% from Howth Head, 3.1% from Lambay Island and <2% from other colonies up to 231 km from the Project. The main colonies are located at least 275 km (at-sea distance) from both Walney and Burbo Bank OWFs, and because black-legged kittiwake foraging range is (mean maximum) 73.2 km, plus one standard deviation (80.5 km) (Woodward *et al.*, 2019), there is very limited potential for these developments to affect breeding season populations (DONG energy, 2013a-b).

5.5.1.25 It is noted that the ranges provided by Woodward *et al.* (2019) only account for foraging activities during the breeding season. However, given the small proportion of the relevant BDMPS predicted to be at risk, it is considered that this level of mortalities would result in negligible effects on the wider biogeographic population (with connectivity to UK waters) outside of the breeding season.

5.5.1.26 Other projects, where only qualitative assessments of collision risk on black-legged kittiwake are available, assess the risk to the species as very low or negligible.

5.5.1.27 Therefore, it is determined that the overall cumulative collision risk effect of the Project, along with the other projects scoped in for CEA, on black-legged kittiwake is **minor adverse** effect, which is not significant in EIA terms.

Chapter 6 Marine Mammals

6.1 Common Dolphin Density Estimates

6.1.1 *Synopsis of comments received: Justification should be provided for using the SCANS III estimate for common dolphin density outside of the survey area based on the ecology of the species or environmental conditions. It is unclear why site-specific surveys have been deemed appropriate for use within the survey area but not impact radii proximate to it.*

6.1.1.1 Table 9 in the baseline report (Volume 3, Technical Appendix 12.1) outlines the different common dolphin density estimates available in the literature and from site-specific surveys of relevance to the Project. These density estimates varied drastically from 0 dolphins/km^2 from some of the Celtic Sea ObSERVE survey months, to 1.61 dolphins/km^2 for the site-specific surveys. The approach presented in the assessment was to use the mean site-specific survey density estimate of 1.61 dolphins/km^2 to the portion of the impact footprint within this survey area, then use the SCANS-III Block D density estimate of 0.3743 dolphins/km^2 for the remainder of the impact footprint beyond the site-specific survey area (Table 6-1).

6.1.1.2 While the Applicant acknowledges that assuming a higher density (1.61 dolphin/km^2) within the site-specific survey area, and a step-change to a lower density (0.3743 dolphins/km^2) for all other surrounding waters is unlikely to be a realistic reflection of the distribution of animals, it does capture some of the patchy distribution of common dolphins in the wider region (e.g., Rogan *et al.*, 2018, Hammond *et al.*, 2021). It is also noted that while sightings of common dolphins in SCANS-III in the wider Project Area were few, Block D does include areas of much higher sightings and predicted densities to the southwest, in the Celtic Sea (see Figure 6-1, below), which are reflected in the overall Block-wide density estimate.

6.1.1.3 Importantly, the application of the site-specific survey area density value to the wider region is highly unrealistic. For example, the SCANS III Block D has a surface area of 48,590 km^2, with an abundance estimate across the block of 18,187 common dolphins (95% CI: 4,394-33,077), corresponding to a density of 0.3743 dolphins/km^2. If the mean site-specific density estimate of 1.61 dolphins/km^2 is assumed across the entire Block D, this would result in an abundance estimate of 78,230 common dolphins, which is 4.3 times higher than estimated by the SCANS III surveys (2.4 times higher than the upper 95% CI).

6.1.1.4 The MU estimate for common dolphins is 102,656 (58,932–178,882) (IAMMWG, 2022). If the SCANS III density data are used, the number of common dolphins within survey Block D represents 18% of the entire MU population. However, if the site-specific density estimate is assumed across the entire survey block, the number of common dolphins within Block D represents 76% of the entire MU population. Therefore, the use of the site-specific density estimate throughout the entire predicted range of impacts, would result in an unrealistically large number of animals impacted, and hugely disproportionate impacts to the MU population.

Table 6-1: Common dolphins in SCANS III Block D.

Density	Area of Block D	# common dolphins	% MU in Block D
SCANS III: 0.3743	48,590 km^2	18,187	18% (10-31%)
HiDef: 1.61	48,590 km^2	78,230	76% (44 – 133%)

6.1.1.5 It has been highlighted by NRW Advisory and JNCC that the SCANS III block wide density estimates are only representative of average densities across the entire survey block, and are not appropriate to use on small scales within a survey block. The Applicant acknowledges this, but highlights that the total impact area from pile driving disturbance (within the 120 dB SEL_{ss} contour) is 29,386.9 km^2, which represents 60% of the area within SCANS III survey Block D. Thus, the potential maximum predicted impact range is not considered by the Applicant to be "*small scale*" within the survey block. As such, the Applicant maintains that it is not unreasonable to use the SCANS III density for this, large, predicted impact area.

6.1.1.6 It is noted that, while the SCANS surveys provide sightings, density and abundance estimates at a wide spatial scale, the surveys are conducted during a single month, every 11 years and therefore do not provide any fine scale temporal or spatial information on species abundance and distribution. Since they are only conducted during the summer months, they are therefore not representative for other seasons in the year. This can be an issue for marine mammal species with seasonal distributions, and there is the potential to overestimate average annual abundances for such species using the SCANS density estimates alone. The Applicant acknowledges that there is uncertainty among the various density estimates available to inform the assessment.

6.1.2 Alternative Density Estimates

SCANS III Modelled Density Surface

6.1.2.1 The SCANS III modelling density surface predicts low densities of common dolphins throughout the maximum piling disturbance impact range. Across most of the impact range, the modelled density is 0.07-0.15 dolphins/km^2, with only the outer extents of the contour reaching cells where the density is between 0.15-0.3 dolphins/km^2 (Figure 6-1). Therefore, if the new modelled SCANS III density surface for common dolphins were to be used, the impact level would be below that presented in ES Volume 1 Chapter 12 Marine Mammals, as the density estimates are lower.

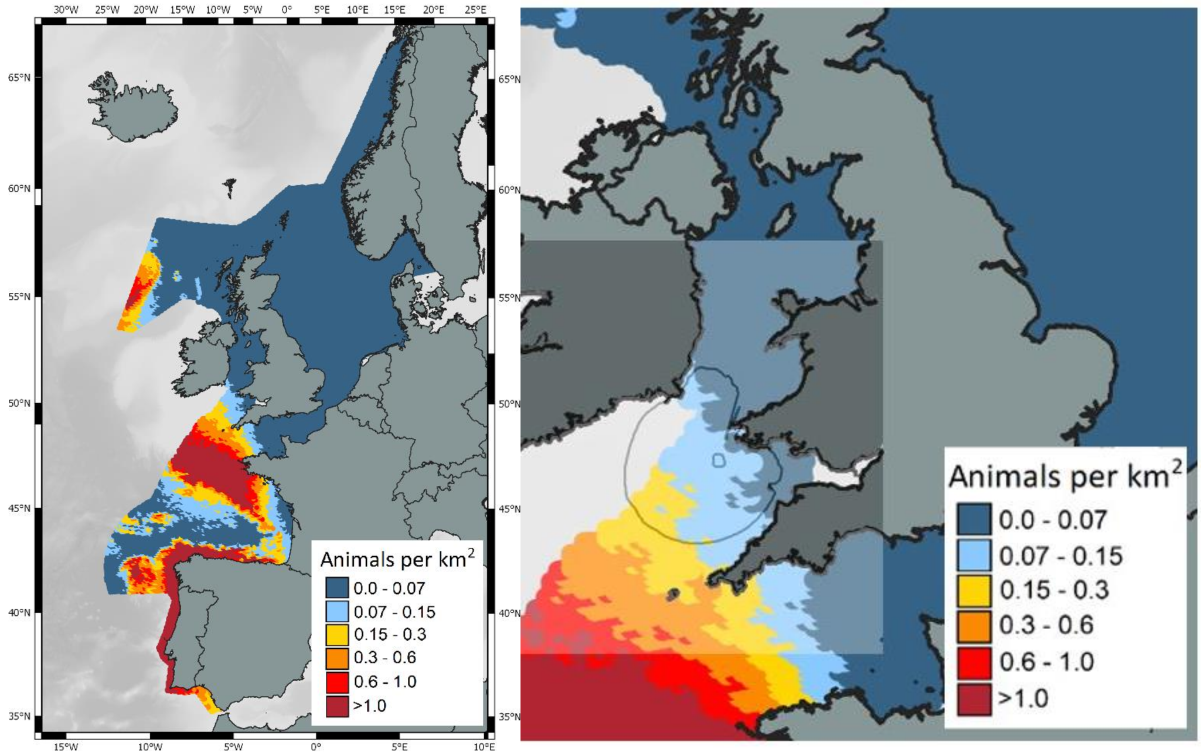


Figure 6-1: GAM predicted density surface for common dolphins from SCANS III (Figure provided by Prof. Phil Hammond). Left = whole SCANS III density surface, right = Erebus maximum disturbance contours overlain on the density surface.

JCP Phase III Atlantic Array Density Estimate

6.1.2.2 An alternative density estimate that could be used for the wider impact area is the Paxton *et al.* (2016) density estimate provided for the Atlantic Array Area (a *c*.20,000 km^2 area covering the Bristol Channel and adjacent Irish Sea; Figure 6-2). Paxton *et al.* (2016) estimate common dolphin density to vary seasonally between 0.12–1.69 dolphins/km^2, with an average of 0.63 dolphins/km^2 across the year. If the density value of 0.63 dolphins/km^2 is used for impact areas beyond the site-specific survey area, this results in predicted disturbance to 3,278 common dolphins, representing 3.19% of the MU. Given the low proportion of the MU predicted to be impacted repeatedly, and the very short-term duration of the impact (piling over a maximum of 18 days), the magnitude of impact is assessed as low, where short-term and/or intermittent and temporary behavioural effects are expected in a small proportion of the population, any impact to vital rates of individuals may occur only in the short term (over a limited number of breeding cycles, <1 in this case), and where any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered. This is the same magnitude conclusion that was reached in the ES and, thus, there is no change to the assessment.

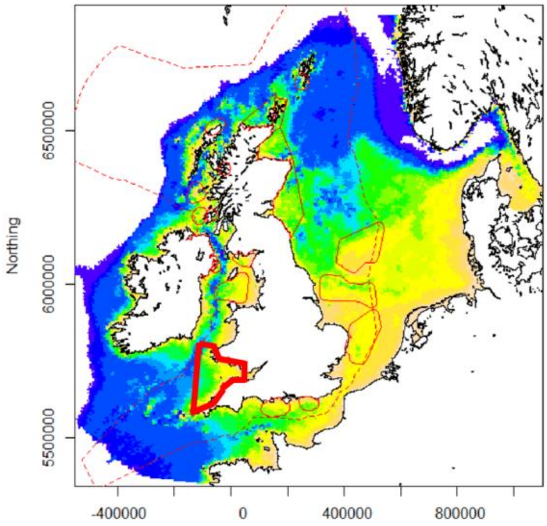


Figure 6-2: The Atlantic Array Area (which covers the Bristol Channel and adjacent Irish Sea). Colour palette represents bathymetry. Image from Paxton *et al.* (2016).

6.1.2.3 However, it is important to stress that Paxton *et al.* (2016) state that the results of the JCP analysis should be considered indicative rather than an accurate representation of species distribution, and that due to the patchy distribution of data, the estimates are less reliable than those obtained from SCANS surveys. Therefore, the Applicant still maintains that the use of the SCANS III density estimate is appropriate.

JCP Phase III Data Analysis Product

6.1.2.4 The JCP Phase III Data Analysis Product[9] was used to obtain an abundance estimate for common dolphin in a user-specified area (shown in green in Figure 6-3). The abundance estimate of common dolphins in this area was 9,182 (6,622-15,010) (this is the summer density estimate averaged for summer 2007-2010). This results in a density estimate of 0.22 common dolphins/km^2 across this area. This is lower than the density estimate from SCANS III. If it is assumed that the density of common dolphins is 1.61 dolphins/km^2 within the Survey Area, and 0.22 dolphins/km^2 beyond the Study Area, then the resulting predicted impact for the pile driving is the disturbance of 1,336 common dolphins (1.30% MU). This is lower than the value predicted in ES Volume 1 Chapter 12 Marine Mammals.

[9] https://hub.jncc.gov.uk/assets/01adfabd-e75f-48ba-9643-2d594983201e

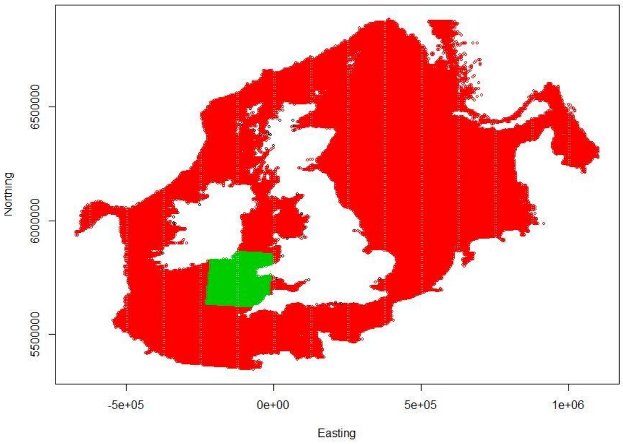


Figure 6-3: User specified area in the JCP Phase III Data Analysis Product.

Site-specific Survey Data

6.1.2.5 The very worst-case scenario would be to assume that the density estimate obtained for the Survey Area is the same throughout the entire disturbance impact zone (noting that this is considered to be unrealistic). The entire impact area, extending out to the 120 dB SEL_{ss} contour would therefore contain an estimated 47,313 common dolphins, which, once the dose response had been applied, results in predicted disturbance impact to 7,919 common dolphins (7.71% MU).

6.1.3 Conclusion

6.1.3.1 As outlined in ES Volume 1 Chapter 12: Marine Mammals, paragraphs 12.6.2.44 *et seq.,* the movement patterns of common dolphins in UK waters are poorly understood and, as such, it is not known how much repeated disturbance an individual dolphin would be expected to receive. The worst-case scenario would consist of the same animals being repeatedly exposed, thus increasing the potential for the repeated disturbance to result in changes to vital rates. Thus, the very worst-case scenario assumes that the same 7,919 common dolphins are disturbed repeatedly over 18 piling days (Table 6-2). Despite the fact that this scenario assumes that >5% of the MU is predicted to experience repeated disturbance, the very short-term duration of the impact (piling over a maximum of 18 days) means that the magnitude of impact remains assessed as **low**, where short-term and/or intermittent and temporary behavioural effects are expected in a small proportion of the population, any impact to vital rates of individuals may occur only in the short term (over a limited number of breeding cycles, <1 in this case) and where any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered. As outlined in ES Volume 1 Chapter 12: Marine Mammals paragraphs 12.6.2.47 *et seq*., the use of the harbour porpoise dose-response curve to predict common dolphin disturbance is highly conservative. The impact assessment can be summarised as:

- Common dolphins have been assessed as having a **Low sensitivity** to disturbance from pile driving;
- The impact of disturbance to common dolphins from pile driving has been assessed a **Low magnitude**, given the short piling duration; and
- Therefore, disturbance from piling activities is concluded to result in a **minor adverse** effect to common dolphins, which is **not significant in EIA terms**.

Table 6-2: Piling disturbance impact assuming various common dolphin densities.

Density source	Density	# Common dolphins
HiDef and JCP Data Tool	1.61 & 0.22	1,336 (1.30% MU)
HiDef and SCANS III modelled density surface (max)	1.61 & 0.3	1,715 (1.67% MU)
HiDef and SCANS III block D	1.61 & 0.3743	2,067 (2.01% MU)
HiDef and JCP Atlantic Array (average)	1.61 & 0.63	3,278 (3.19% MU)
HiDef only	1.61	7,919 (7.71% MU)

6.2 Harbour Porpoise Density Estimate

6.2.1.1 ***Synopsis of comments received:*** *It is unclear why, for common dolphin, site-specific surveys have been deemed appropriate for use within the survey area but not impact radii proximate to it, but that use of the site-specific survey density estimates throughout impact radii has been considered suitable for harbour porpoise.*

6.2.1.2 ES Volume 3 Technical Appendix 12.2, Table 16, outlines the different harbour porpoise density estimates. As shown in the marine mammal impact assessment chapter, the disturbance contours for pile-driving extend far beyond the Survey Area. However, other density estimates in the general Bristol Channel and adjacent Irish Sea area (0.31-0.44 porpoise/km^2) are similar to those recorded during the site-specific surveys (0.4 porpoise/km^2); therefore, in the case of harbour porpoise, the density estimate of 0.4 porpoise/km^2 (obtained from the site-specific surveys) is considered to be appropriate to apply to the entire impact range, and not just the site-specific survey area.

6.2.1.3 This approach differs to that taken for common dolphins because the site-specific density estimate for common dolphins was vastly different to other density estimates in the area, whereas the site-specific density estimate for harbour porpoise was very similar to other density estimates in the area.

6.3 Cable Snapping Noise

6.3.1.1 ***Synopsis of comments received:*** *An assessment of the impact of cable ‘snapping’ should be conducted on marine mammals. JNCC also consider this a viable impact pathway for disturbance, and request that it be assessed.*

6.3.1.2 Cable 'snapping' refers to the sudden re-tension in a cable following a period of slackness resulting from large amplitude and/or high-frequency surface motions (Liu, 1973). Whilst mooring cables are designed to be permanently in tension and, therefore, should not go slack even in extreme conditions (partly to avoid the risk of marine mammal entanglement) (Statoil, 2015), it is considered that mooring lines and cables associated with floating OWFs have the potential to produce snapping noises during the operational phase of the development, as the presence of a snapping sound was identified at the Hywind Demonstrator Project in Norway (Martin *et al.*, 2011). However, due to the relatively small number of floating WTGs currently installed and operational, and the variability in their configuration, the availability of underwater operational noise is limited and there is a knowledge gap regarding the dynamic movement of the cables that link the floating WTGs (Rentschler *et al.*, 2019).

6.3.1.3 Data are available for the Hywind Demonstrator Project for a single WTG, where noise measurements were taken at 91 m off the seabed, in water depths of 200 m, (i.e. approximately mid-depth), at 150 m from the installation (Martin *et al.*, 2011). During the 2-month monitoring period, up to 23 snaps were identified per day. Of these, fewer than 10 snaps per day exceeding an SPL_{peak} of 160 dB re 1 μPa were identified on most days. As the precise source of the noise could not be determined, the exact distance from the monitoring location cannot be ascertained and, therefore, a prediction of the noise closer to the source is not possible for estimation of PTS, in terms of SPL_{peak}.

6.3.1.4 Subsequent analysis undertaken for the Hywind Scotland Pilot Park Project (Xodus Group Ltd, 2015) predicted a potential cumulative SEL of up to 156 dB re 1 $\mu Pa^2 s$ over 24 hours at 150 m resulting from cable snapping. This value is below the onset criteria for hearing injury (PTS) to marine mammals and, therefore, means that, should any snaping noise occur, it will not result in injury. Therefore, there is considered to be **no risk of PTS from cable snapping**.

6.3.1.5 In terms of disturbance, there are currently no reliable disturbance thresholds that would be recommended for the kind of intermittent/rare impulses that would be generated from cable snapping. Statoil (2015) used the 140 dB re 1 μPa (rms) criterion for mild behavioural disturbance to marine mammals for impulsive sounds in the Hywind Scotland impact assessment, and found that this would be exceeded up to approximately 250 m from each WTG, and that a strong behavioural disturbance would be experienced within approximately 30 m of each WTG. As this assessment used impulsive noise thresholds, it likely represents an overestimate of the potential behavioural disturbance. Therefore, as cable snapping has been determined to occur at an average rate of less than once per hour, disturbance resulting in avoidance behaviour is considered to be unlikely. Due to the extremely localised impact range, disturbance resulting from cable snapping is considered to be of **negligible magnitude**.

6.3.1.6 The following information from the Blue Gem Wind engineers (pers. comm. July 2022) on the difference between Hywind's and The Project's mooring system should also be noted:

- *"Hywind's mooring system is different to Erebus. The drift of the platform is stopped once the mooring line forms a straight line between Fairlead and Anchor. The mooring line is fully metallic, it has a very high axial stiffness, thus a high load in the mooring line is induced at that moment. Which by consequence provokes relatively high, strong vibrations accompanied by noise emissions;*

- *For Erebus, the mooring system is designed to always have a piece of it that is catenary, at least the bottom part (a piece of the mooring chain will always remain laying on the seabed to avoid uplift at the drag embedment anchor); the axial stiffness of the mooring line never enters in play. When the Hull is drifting, the motion is slowed down smoothly until the Hull is stopped (including in extreme conditions). The mooring system has a small portion of fiber rope that make this even smoother (lowering the risks of snapping noise). The mooring line is always under load (never null; never under compression), thus no snatch loads are expected (nor associated noise)."*

6.3.1.7 Therefore, the impact pathway of cable 'snapping' noise is **not expected to occur at The Project**.

6.3.1.8 Despite this, the Applicant is willing to **commit to monitoring O&M underwater noise levels**. The timing, extent and duration of this monitoring will be determined in discussion with NRW Advisory and JNCC, post-consent.

6.4 Cumulative PTS

6.4.1.1 ***Synopsis of comments received:*** *Acknowledge that there is evidence to support estimates of PTS impact ranges based on SEL_{cum} being precautionary. However, disagree that there is sufficient evidence presented (i.e., the equal energy hypothesis) for the SEL_{cum} metric to be considered invalid and not presented in the assessment.*

6.4.2 Precaution

6.4.2.1 The Applicant maintains that, at present, the estimation of SEL_{cum} PTS onset ranges is highly over-precautionary and, as such, there should not be a requirement to implement mitigation based on SEL_{cum} until these conservatisms have been quantified and addressed. The current underwater noise modelling for SEL_{cum} PTS onset using the Southall *et al.* (2019) criteria assumes the following:

- The amount of sound energy an animal is exposed to within 24 hours will have the same effect on its auditory system, regardless of whether it is received all at once (i.e. within a single bout of sound) or in several smaller doses spread over a longer period; and
- The sound retains its impulsive character, regardless of the distance to the sound source.

6.4.2.2 However, in practice:

- There is recovery of a threshold shift, if the dose is applied in several smaller doses (e.g. between pulses during pile driving or in piling breaks) leading to an onset of PTS at a higher energy level than assumed with the given SEL_{cum} threshold; and
- Impulsive sound loses its impulsive characteristics while propagating away from the sound source, resulting in a slower shift of an animal's hearing threshold than would be predicted for an impulsive sound.

6.4.2.3 Both assumptions therefore lead to a conservative determination of the impact ranges.

6.4.2.4 Several studies (on bottlenose dolphins, harbour porpoise and California sea lions) have shown that for the same SEL_{cum}, if duty cycle decreases (i.e. the interval between successive impulses, such as gaps between hammer strikes of piles), then the magnitude of TTS decreases (Finneran *et al.*, 2010b, Finneran *et al.*, 2010a, Kastelein *et al.*, 2014, Kastelein *et al.*, 2015, Kastelein *et al.*, 2021, Kastelein *et al.*, 2022). In such experiments, while the total amount of received energy is the same, the energy received per unit of time differs under different duty cycles, influencing the resulting TTS. Therefore, when exposed to sounds with a lower duty cycle, TTS develops more slowly. Kastelein *et al.* (2014) showed that when a harbour porpoise was exposed to a SEL_{cum} of 204 dB re 1 μPa²s, a 100% duty cycle resulted in an initial TTS of 27.5 dB, a duty cycle of 75% resulted in an initial TTS of 21.3 dB, a duty cycle of 50% resulted in an initial TTS of 19.8 dB and a duty cycle of 25% resulted in an initial TTS of 17.4 dB. Kastelein *et al.* (2015) showed that the 40 dB hearing threshold shift proposed by Southall *et al.* (2007) for harbour porpoise is expected to be reached at different SEL_{cum} levels depending on the duty cycle (Figure 6-4): for a 100% duty cycle, the 40 dB hearing threshold shift is predicted to be reached at a SEL_{cum} of 196 dB re 1 μPa²s, but for a 10% duty cycle, the 40 dB hearing threshold shift is predicted to be reached at a SEL_{cum} of 206 dB re 1 μPa²s (10 dB re 1 μPa²s difference in the threshold).

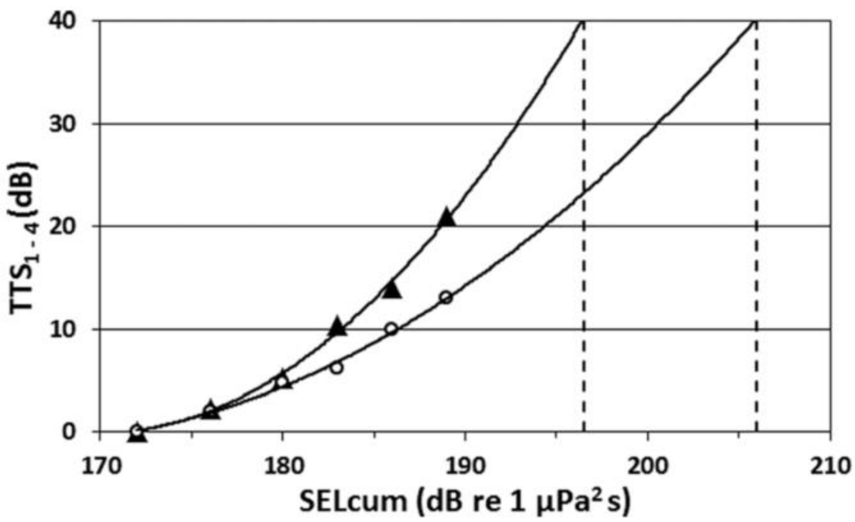


Figure 6-4: The effect of the SEL_{cum} on TTS in a harbour porpoise (○ = duty cycle 10, ▲ = 100% duty cycle). Figure from Kastelein *et al.* (2015).

6.4.2.5 Pile strikes are relatively short signals; the signal duration of monopile pile strikes may range between 0.1 sec (De Jong and Ainslie, 2008) and approximately 0.3 sec (Dähne *et al.*, 2017) measured at 3.3-3.6 km. The strike rate at The Project varies across the expected piling period, between 10 strikes/min (soft-start) to 30 strikes/min (ramp-up and full hammer energy). Assuming the pile strike is 0.3 sec in duration, the soft-start will have a duty cycle of 5% (0.3 sec strike followed by 5.7 sec silence), and the ramp-up/full hammer energy will have a duty cycle of 15% (0.3 sec strike followed by 1.7 sec silence). Therefore, it is expected that at The Project, the very low duty cycles (5-15%) will result in a significantly smaller TTS than if 100% duty cycle was assumed. Thus, the currently presented SEL_{cum} PTS onset impact ranges, which do not account for duty cycle and recovery between pulses, are highly conservative.

6.4.3 Draft Marine Mammal Mitigation Plan

6.4.3.1 Table 3 in the draft MMMP (ES Volume 3, Technical Appendix 12.3) details the maximum instantaneous PTS-onset impact ranges from pile driving. The largest impact range is for harbour porpoise (280 m). To be precautionary, the draft MMMP recommends a 500 m mitigation zone be monitored, and that a combination of MMO, PAM and piling soft-start is sufficient mitigation.

6.4.3.2 Table 4 in the draft MMMP (ES Volume 3, Technical Appendix 12.3) details the maximum cumulative PTS-onset impact ranges from pile driving. The largest impact range is for minke whales (2.7 km) (note: the maximum range for all other species is <100 m). The Applicant maintains that there should not be a requirement to mitigate cumulative PTS, given the issues with the current modelling methods. However, as requested by NRW Advisory, the Applicant has provided the following assessment.

6.4.3.3 An impact range of 2.7 km is beyond that typically monitored by visual observers. As such, additional methods would be required to ensure the mitigation zone was free of minke whales. One option is the use of an acoustic deterrent device to deter animals out of the mitigation zone. The only data on minke whale responses to ADDs show that all animals within 1 km of experimental 15-min exposures responded, which demonstrates an effective deterrence effect to at least 1 km (McGarry *et al.*, 2017, Boisseau *et al.*, 2021). Several animals continued to swim further away, to a distance of between c. 3 km and 4.5 km following exposure, however no measurements were made with ADDs activated at initial distances >1 km from the focal animal, and the visual limit of observations limited how far responding animals could be observed, so it is not known what the maximum effective deterrence range is. These data provide some evidence that minke whales can be deterred by ADDs within at least 1 km. However, there is insufficient evidence to ensure that ADDs could mitigate the entire 2.7 km range cumulative PTS mitigation zone.

6.4.3.4 While the cumulative PTS onset impact range is 2.7 km for minke whales, the density of minke whales in the area is so low that a maximum of only 1 whale is expected to experience PTS on any piling day. When using ADDs to mitigate risk of injury, it is important to balance this risk with the subsequent associated disturbance effects, particularly to harbour porpoise which have been reported to exhibit deterrence effects to many kilometres from even short ADD exposures (Thompson *et al.*, 2020).

6.4.3.5 Other mitigation options such as at source-noise abatement methods take time to deploy and recover, and typically require the use of additional vessels. As such, they have the potential to increase both the duration and potential spatial extent (e.g., see Benhemma-Le Gall *et al.*, 2021) of disturbance to marine mammals. Therefore, it was considered that the use of a bubble curtain would likely cause more of a negative disturbance effect (due to increased vessel time, deployment and recovery of equipment), than it would provide in noise reduction benefits to mitigate impact to one individual whale. As such, the Applicant suggests that the potential for injury to minke whales, and associated final decisions on appropriate mitigation measures, is determined via EPS licensing at a later stage in Project Development, and based on the state of knowledge and best modelling practice available at the time.

6.4.3.6 It is noted that the procedures presented in the draft MMMP (ES Volume 3, Technical Appendix 12.3) are sufficient to mitigate both instantaneous and cumulative PTS to all other marine mammal species.

6.4.4 Conclusion

6.4.4.1 The Applicant acknowledges that the assessment of cumulative PTS is an area of active research. Ongoing studies are seeking to better understand the effects of duty cycle and how the impulsive characteristics of noise change with range; for example, further investigation of how duty cycle influences TTS in harbour porpoise and seals (R. Kastelein, pers. comm., April 2022), and the forthcoming (2022) ORJIP RaDIN (range-dependent nature of impulsive noise) Project. It is anticipated that these, and other, studies will reduce existing uncertainties and sources of conservatism, and will result in developments to the process of estimating SEL_{cum}. As such, the Applicant will maintain awareness of current research and maintain ongoing dialogue with NRW Advisory and JNCC as the Project develops to ensure that the final MMMP presents an assessment and mitigation measures reflecting the state of knowledge and best modelling practice available at the time.

6.4.4.2 Thus, **the Applicant is content to agree that cumulative PTS will be mitigated in the final MMMP**. Potential mitigation options that will be considered in the final MMMP to mitigate PTS (both instantaneous and cumulative) include:

- Alternative anchoring options (e.g. drag embedment anchors);
- Marine mammal observers to ensure the mitigation zone is free of marine mammals prior to piling commencing;
- Acoustic deterrent device to ensure the mitigation zone is free of marine mammals prior to piling commencing;
- Passive Acoustic Monitoring to ensure the mitigation zone is free of marine mammals prior to piling commencing;
- At-source noise abatement systems (e.g. bubble curtains, casings, resonators); and
- Alternative hammer types (e.g. vibro-piling, BLUE piling technology).

6.5 Risso’s Dolphin Assessment

6.5.1.1 ***Synopsis of comments received:*** *An appropriately detailed assessment and conclusion should still be conducted for Risso’s dolphin based on the specific ecology of the species and clear conclusions reached. For example, how the proportion of the relevant management unit may differ to that for other dolphin species.*

6.5.1.2 Risso’s dolphin have a range that extends across ocean basins and, although they occur in all habitats from coastal to oceanic, they prefer mid-temperate waters of the continental shelf and slope between 30° and 45° latitude (Jefferson *et al.*, 2014). Risso’s dolphins have been commonly sighted around the north and west of the British Isles, to around 60°N, which is likely to reflect the warming influence of the Gulf Stream (Jefferson *et al.*, 2014). Their diet consists of cephalopods (primarily squid), crustaceans and occasionally small fish (MacLeod *et al.*, 2014). They are typically encountered in groups of up to 20, but may form larger aggregations (Reid *et al.*, 2003). The population structure of Risso’s dolphin is poorly understood, and a single MU encompassing all UK waters is considered appropriate (with an abundance estimate of 12,262) (IAMMWG, 2022), although there is limited evidence for seasonal and long-term site fidelity to shallow waters in Cardigan Bay, Wales, for a small group of animals (de Boer *et al.*, 2013). The species is not known for undertaking large migrations but movement within local distribution areas following prey resources is expected.

6.5.1.3 The baseline data provided very limited evidence of Risso's dolphin presence at the site (array area and ECC) and, therefore, this species was scoped out of quantitative impact assessment. As noted in various places in the impact assessment chapter, the PTS and TTS impact ranges for Risso's dolphins are the same as for the other dolphin species, as they also belong to the high frequency functional hearing group. Given that no density estimate is available for Risso's dolphins, no predicted number of impacted animals is included. It is expected that the density, and thus resulting number of Risso's dolphins impacted, would be less than that for bottlenose dolphins. Similarly, the size of the relevant management unit for Risso's dolphins (Celtic and Greater North Seas = 12,262) is larger than that for bottlenose dolphins (The Offshore Channel and SW England = 10,974), and so the number of impacted Risso's dolphins would represent a lower proportion of the Management Unit than that for bottlenose dolphins. Therefore, it follows, that since there was no significant impact predicted for bottlenose dolphins, there is not expected to be any significant impact to Risso's dolphins. It is also noted that the Project Area is located some 35 km from the Pembrokeshire coast, which represents the nearest reported area of elevated Risso's dolphin sightings, relative to the rest of the UK and Ireland coastline.

6.5.2 Impact Summary

6.5.2.1 **PTS and disturbance:** (see sections below for more information on sensitivity and magnitude scores for PTS and disturbance). For all PTS impact pathways, Risso's dolphins are considered alongside bottlenose dolphins as 'high frequency cetaceans' and, thus, the impact ranges are the same. The impact to Risso's dolphin is expected to be less than that of bottlenose dolphins, since the density is lower and the MU is larger. Therefore, it follows that since there was no significant impact predicted for bottlenose dolphins, there is not expected to be any significant impact to Risso's dolphins.

6.5.2.2 For all disturbance impact pathways, it is assumed that Risso's dolphins have the same sensitivity to disturbance as bottlenose dolphins, as they are both classified as 'high frequency cetaceans'. The impact to Risso's dolphin is expected to be less than that of bottlenose dolphins since the density is lower and the MU is larger. Therefore, it follows that since there was no significant impact predicted for bottlenose dolphins, there is not expected to be any significant impact to Risso's dolphins.

6.5.2.3 **Collision and disturbance from vessels:** As per the assessment for all other marine mammals, as presented in ES Volume 1, Chapter 12: Marine Mammals.

6.5.2.4 **Impacts on prey:** In the UK, Risso's dolphin diet consists mainly of cephalopods (octopus, cuttlefish, squid) (Clarke and Pascoe, 1985). ES Volume 1 Chapter 10: Fish and Shellfish Ecology found no significant impact to cephalopods and, as such, the indirect impacts on prey are expected to have a **negligible** magnitude. Risso's dolphins are considered to have a more specialist diet compared with the other marine mammal considered in this assessment (see ES Volume 1 Chapter 12: Marine Mammals Table 12.26 – key prey species). Therefore, is it precautionary to assess them as having a **medium** sensitivity to impacts on prey species, as they may have limited tolerance to changes in cephalopod prey distribution and abundance.

6.5.2.5 **Barrier effects and entanglement:** As per the assessment for all other marine mammals, as presented in ES Volume 1 Chapter 12: Marine Mammals.

6.5.2.6 Conclusions of the impact assessment for Risso's dolphin are summarised in Table 6-3.

Table 6-3: Conclusion of the impact assessment for Risso's dolphins.

Impact	Sensitivity	Magnitude	Significance
PTS from UXO	Medium	Negligible (UXO MMMP)	Minor (not significant)
Disturbance from UXO	Low	Low	Minor (not significant)
PTS from piling	Medium	Negligible (Piling MMMP)	Minor (not significant)
Disturbance from piling	Low	Low	Minor (not significant)
PTS from other construction activities	Low	Negligible	Negligible (not significant)
Disturbance from other construction activities	Low	Low	Minor (not significant)
Collision with vessels	High	Negligible (VMP)	Minor (not significant)
Disturbance from vessels	Low	Low (VMP)	Minor (not significant)
Impacts on prey	Medium	Negligible	Minor (not significant)
Barrier effects	Negligible	Negligible	Negligible (not significant)
Entanglement	High	Negligible (ROV surveys)	Minor (not significant)

6.6 Sensitivity, Magnitude and Significance

6.6.1.1 ***Synopsis of comments received:*** *Both NRW Advisory and JNCC have requested that additional information be provided to justify the sensitivity and magnitude scores assigned to each impact pathway.*

6.6.1.2 These are provided in the following sections.

6.6.2 Low-Order and High-Order UXO Detonation – PTS

Sensitivity

6.6.2.1 ***Synopsis of comments received:*** *NRW Advisory are not able to agree with a sensitivity score of 'low' for PTS from high-order UXO detonation based on the information currently presented.*

6.6.2.2 Most of the acoustic energy produced by a high-order detonation is below a few hundred Hz, decreasing on average by about SEL 10 dB per decibel above 100 Hz, and there is a pronounced drop-off in energy levels above ~5-10 kHz (von Benda-Beckmann *et al.*, 2015, Salomons *et al.*, 2021). Therefore, the primary acoustic energy from a high-order UXO detonation is below the region of greatest sensitivity for most marine mammal species considered here (Southall *et al.*, 2019). If PTS were to occur within this low frequency range, it would be unlikely to result in any significant impact to vital rates. Therefore, the Applicant maintains that a **Low** sensitivity of marine mammals to PTS from UXO detonation is an appropriate sensitivity score.

6.6.2.3 Given that the expert elicitation for the effect of PTS on vital rates showed larger confidence intervals for the bottlenose dolphins results, compared with other species, the Applicant is content to increase the sensitivity of bottlenose dolphins to PTS to **Medium** to be precautionary. In the absence of information on common and Risso's dolphins, the sensitivity to PTS from piling is assumed to be the same as that for bottlenose dolphins, since all three species are classified as "*high frequency cetaceans*" in Southall *et al.* (2019) and are thus expected to have similar hearing abilities.

Magnitude

6.6.2.4 The magnitude is assessed as **Negligible** for all species, as the Project is adhering to a UXO MMMP, which will ensure the risk of PTS from UXO clearance is negligible.

Significance

6.6.2.5 There is no significant impact to any marine mammal species for PTS from UXO clearance activities (both high- and low-order clearance; Table 6-4).

Table 6-4: Conclusion for the impact of PTS from UXO clearance (both high- and low-order).

Species	Sensitivity	Magnitude	Significance
Common dolphin	Medium	Negligible	Minor (not significant)
Bottlenose dolphin	Medium	Negligible	Minor (not significant)
Risso's dolphin	Medium	Negligible	Minor (not significant)
Harbour porpoise	Low	Negligible	Negligible (not significant)
Minke whale	Low	Negligible	Negligible (not significant)
Grey seal	Low	Negligible	Negligible (not significant)

6.6.3 Low-Order UXO Detonation – Disturbance

Sensitivity

6.6.3.1 It is noted in the JNCC (2020) guidance that *"...a one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement..."*. Therefore, it is not expected that disturbance from a single low-order UXO detonation would result in any significant impacts, and that disturbance from a single noise event would not be sufficient to result in any changes to the vital rates of individuals. Therefore, the sensitivity of marine mammals for disturbance from UXO clearance is expected to be **Low**.

Magnitude – 5 km EDR

6.6.3.2 Table 12.14 in ES Volume 1, Chapter 12: Marine Mammals, details the disturbance impact for low order UXO detonation, assuming a 5 km EDR. Given the low number and percentage of the respective MUs expected to be disturbed by low-order clearance of a UXO, the effect on all marine mammal receptors is considered to be of **negligible** magnitude.

Magnitude – TTS as a proxy for disturbance

6.6.3.3 ***Synopsis of comments received:*** *NRW Advisory recommend that TTS as a proxy for disturbance is presented for low-order UXO clearance activities, in addition to the 5 km EDR approach presented in Chapter 12.*

6.6.3.4 Table 6-5 provides the TTS-onset impact ranges (as a proxy for disturbance) for both a 0.25 kg NEQ low-order charge (most likely), and a 2 kg NEQ low-order charge (worst-case). Even under the worst-case scenario, disturbance is predicted to <1 animal for dolphins and seals. This is of negligible magnitude. A maximum of 88 minke whales, and 166 harbour porpoise, are expected to experience disturbance, representing only 0.44% and 0.27% of each MU respectively. Given the low proportion of the MU predicted to be impacted, and the very short-term duration of the impact (1 clearance event on a single day), the magnitude of impact is assessed as **Low**, where short-term and/or intermittent and temporary behavioural effects are expected in a small proportion of the population, any impact to vital rates of individuals may occur only in the short term (over a limited number of breeding cycles, <1 in this case) and where any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered.

Table 6-5: TTS-onset impact ranges (as a proxy for disturbance) for both a 0.25 kg NEQ low-order charge (most likely) and a 2 kg NEQ low-order charge (worst-case).

Functional hearing group	Density (animals/km^2)	0.25 kg			2 kg		
		Range	# animals	Magnitude	Range	# animals	Magnitude
TTS unweighted SPL_{peak}							
LF	0.0112	320 m	<1	Negligible	650 m	<1	Negligible
HF	Bottlenose: 0.063 Common: 1.61	100 m	<1 <1	Negligible	320 m	<1 <1	Negligible
VHF	0.4	1,800 m	4	Negligible	3,600 m	166 (0.27% MU)	Low
PCW	0.041	360 m	<1	Negligible	720 m	<1	Negligible
TTS weighted SEL_{cum}							
LF	0.0112	3,200 m	<1	Negligible	8,800 m	88 (0.44% MU)	Low
HF	Bottlenose: 0.063 Common: 1.61	20 m	<1 <1	Negligible	50 m	<1 <1	Negligible
VHF	0.4	750 m	1	Negligible	1,300 m	4	Negligible
PCW	0.041	570 m	<1	Negligible	1,500 m	<1	Negligible

Significance

6.6.3.5 The magnitude of the impact has been assessed as either Negligible or Low, and the sensitivity of marine mammal receptors as Low. Therefore, disturbance from low-order UXO detonation is concluded to result in a **Negligible** or **Minor** adverse effect, which is not significant in EIA terms (Table 6-6).

Table 6-6: Conclusion for the impact of disturbance from UXO clearance (low-order).

Assessment	Species	Sensitivity	Magnitude	Significance
Disturbance 5 km EDR	Common dolphin	Low	Negligible	Negligible (not significant)
	Bottlenose dolphin	Low	Negligible	Negligible (not significant)
	Risso's dolphin	Low	Negligible	Negligible (not significant)
	Harbour porpoise	Low	Negligible	Negligible (not significant)
	Minke whale	Low	Negligible	Negligible (not significant)
	Grey seal	Low	Negligible	Negligible (not significant)
TTS as a proxy for disturbance from UXO (low order)	Common dolphin	Low	Negligible	Negligible (not significant)
	Bottlenose dolphin	Low	Negligible	Negligible (not significant)
	Risso's dolphin	Low	Negligible	Negligible (not significant)
	Harbour porpoise	Low	Low	Minor (not significant)
	Minke whale	Low	Low	Minor (not significant)
	Grey seal	Low	Negligible	Negligible (not significant)

6.6.4 High-Order UXO Detonation – Disturbance

Sensitivity

6.6.4.1 It is noted in the JNCC (2020) guidance that *"...a one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement..."*. Therefore, it is not expected that disturbance from a single high-order UXO detonation would result in any significant impacts, and that disturbance from a single noise event would not be sufficient to result in any changes to the vital rates of individuals. Therefore, the sensitivity of marine mammals for disturbance from UXO clearance is expected to be **Low**.

Magnitude

6.6.4.2 Table 12.16 in ES Volume 1 Chapter 12: Marine Mammals, outlines the number of animals potentially disturbed by high-order UXO clearance, assuming a 26 km EDR. Paragraph 16.6.2.24 in ES Volume 1 Chapter 12: Marine Mammals, outlines the **Low** magnitude score.

<u>Significance</u>

6.6.4.3 The magnitude of the impact has been assessed as **Low** and the sensitivity of marine mammal receptors as **Low**. Therefore, disturbance from high-order UXO detonation is concluded to result in a **minor adverse** effect, which is not significant in EIA terms (Table 6-7).

Table 6-7: Conclusion for the impact of disturbance from UXO clearance (high-order).

Assessment	Species	Sensitivity	Magnitude	Significance
Disturbance 26 km EDR	Common dolphin	Low	Low	Minor (not significant)
	Bottlenose dolphin	Low	Low	Minor (not significant)
	Risso's dolphin	Low	Low	Minor (not significant)
	Harbour porpoise	Low	Low	Minor (not significant)
	Minke whale	Low	Low	Minor (not significant)
	Grey seal	Low	Low	Minor (not significant)
TTS as a proxy for disturbance from UXO (high-order)	Common dolphin	Low	Negligible	Negligible (not significant)
	Bottlenose dolphin	Low	Negligible	Negligible (not significant)
	Risso's dolphin	Low	Negligible	Negligible (not significant)
	Harbour porpoise	Low	Low	Minor (not significant)
	Minke whale	Low	Low	Minor (not significant)
	Grey seal	Low	Negligible	Negligible (not significant)

6.6.5 PTS from Pile Driving

<u>Sensitivity</u>

6.6.5.1 The sensitivity of marine mammals to PTS from pile driving is detailed in ES, Volume 1 Chapter 12: Marine Mammals Sensitivity to PTS. *NRW Advisory recommends the sensitivity score for bottlenose dolphin to permanent threshold shift (PTS) of 'low', be increased 'medium'.*

6.6.5.2 Given that the expert elicitation for the effect of PTS on vital rates showed larger confidence intervals for the bottlenose dolphins results compared to other species, the Applicant is content to increase the sensitivity of bottlenose dolphins to PTS to Medium to be precautionary. In the absence of information on common and Risso's dolphins, the sensitivity to PTS from piling is assumed to be the same as that for bottlenose dolphins, since all three species are classified as "*high frequency cetaceans*" in Southall *et al.* (2019) and are, thus, expected to have similar hearing abilities.

Magnitude

6.6.5.3 The magnitude is assessed as **Negligible** for all species, as the Project is adhering to a piling MMMP which will ensure the risk of PTS from pile driving is negligible.

Significance

6.6.5.4 There is no significant impact to any marine mammal species from PTS from pile driving activities (Table 6-8).

Table 6-8: Conclusion for the impact of PTS from pile driving.

Species	Sensitivity	Magnitude	Significance
Common dolphin	Medium	Negligible	Minor (not significant)
Bottlenose dolphin	Medium	Negligible	Minor (not significant)
Risso's dolphin	Medium	Negligible	Minor (not significant)
Harbour porpoise	Low	Negligible	Negligible (not significant)
Minke whale	Low	Negligible	Negligible (not significant)
Grey seal	Low	Negligible	Negligible (not significant)

6.6.6 Disturbance from Pile Driving

Sensitivity

6.6.6.1 The sensitivity of marine mammals to disturbance from pile driving is detailed in ES, Volume 1 Chapter 12: Marine Mammals for bottlenose dolphin (12.4.8.17 *et seq.*), porpoise (12.4.8.26 *et seq.*), minke whale (12.4.8.37 *et seq.*) and grey seal (12.4.839 *et seq.*).

6.6.6.2 In the absence of any information on the sensitivity of common or Risso's dolphins from pile driving, they were assumed to be the same as bottlenose dolphins: **Low**.

Magnitude – Dose-response Curve

6.6.6.3 The magnitude of impact from disturbance to pile driving is detailed in ES Volume 1 Chapter 12: Marine Mammals Disturbance from pile driving. Given the low number of piling days (18 days max.) and the small proportion of the MU predicted to be impacted per piling day, this was assessed as Negligible (minke whale and grey seal) – Low (common dolphin, bottlenose dolphin, harbour porpoise), depending on the species (Table 12.20 in ES, Volume 1 Chapter 12: Marine Mammals).

6.6.6.4 As detailed previously, the density of Risso's dolphins is expected to be lower than that of bottlenose dolphins, since they were not confidently identified on any of the site-specific surveys. If it is conservatively assumed that the density of Risso's dolphin is the same as bottlenose dolphins (0.063 dolphins/km^2), then the worst-case scenario results in disturbance to 310 Risso's dolphins, which represents 2.5% of the MU. This is of similar magnitude as the predicted impact to the bottlenose dolphin MU and, as such, it is expected that the magnitude of impact will be the same as for bottlenose dolphins. The worst-case scenario would consist of the same animals being repeatedly exposed, thus increasing the potential for the repeated disturbance to result in changes to vital rates. However, given the low proportion of the MU predicted to be impacted repeatedly, and the very short-term duration of the impact (piling over a maximum of 18 days), the magnitude of impact is assessed as Low. As detailed for common and bottlenose dolphins, it was considered to be conservative to use the harbour porpoise dose-response curve for dolphins, since harbour porpoise have a lower auditory injury threshold (i.e. higher hearing sensitivity) than common dolphins (Southall *et al.*, 2019) and are considered to be particularly responsive to anthropogenic disturbance, whereas studies have shown that dolphin species show comparatively less of a disturbance response from underwater noise compared with harbour porpoise (e.g., Kastelein *et al.*, 2006, Culloch *et al.*, 2016).

Magnitude – 26 km EDR

6.6.6.5 ***Synopsis of comments received:*** *JNCC has requested that for comparison, the harbour porpoise disturbance assessment should also present the predicted impact using the 26 km EDR approach.*

6.6.6.6 The following provides an assessment of disturbance from pile driving, assuming a 26 km EDR. Under the assumption that the density of harbour porpoise is 0.4 porpoise/km^2 throughout the impact range, the dose-response curve approach predicts significantly more harbour porpoise are disturbed from pile driving activities, compared with the 26 km EDR method (Table 6-9).

Table 6-9: Comparison of dose-response and EDR approach to assess disturbance to porpoise from pile driving.

Approach	# porpoise	% MU	Magnitude
Dose-response curve	1,967	3.15	Low
26 km EDR	849	1.36	Low

Significance

6.6.6.7 There is no significant impact to any marine mammal species from disturbance from pile driving activities (Table 6-10).

Table 6-10: Conclusion for the impact of disturbance from pile driving.

Species	Sensitivity	Magnitude	Significance
Common dolphin	Low	Low	Minor (not significant)
Bottlenose dolphin	Low	Low	Minor (not significant)
Risso's dolphin	Low	Low	Minor (not significant)
Harbour porpoise	Low	Low	Minor (not significant)
Minke whale	Low	Low	Minor (not significant)
Grey seal	Low	Negligible	Negligible (not significant)

6.6.7 PTS from Other Construction Activities (Continuous Noise Sources)

Sensitivity

6.6.7.1 **Dredging:** Dredging is described as a continuous broadband sound source, with the main energy below 1 kHz (however, the frequency and sound pressure level can vary considerably depending on the equipment, activity, and environmental characteristics) (Todd *et al.*, 2015). The source level of dredging has been described to vary between SPL 172-190 dB re 1 μPa at 1 metre, with a frequency range of 45 Hz to 7 kHz (Evans, 1990, Thompson *et al.*, 2009, Verboom, 2014). It is expected that the underwater noise generated by dredging will be below the PTS-onset threshold (Todd *et al.*, 2015) and, thus, the risk of injury is unlikely, though disturbance may occur. For most marine mammal species considered here, the hearing sensitivity below 1 kHz is relatively poor and, thus, it is expected that a PTS at this frequency would result in little impact to vital rates. Therefore, the sensitivity of marine mammals to PTS from dredging is assessed as **Low**.

6.6.7.2 **Trenching:** Underwater noise generation during cable trenching is highly variable and dependent on the physical properties of the seabed that is being cut. At the North Hoyle OWF, trenching activities had a peak energy between 100 Hz – 1 kHz and, in general, the sound levels were generally only 10-15 dB above background levels (Nedwell *et al.*, 2003). For most marine mammal species considered here, the hearing sensitivity below 1 kHz is relatively poor and, thus, it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of marine mammals to PTS from trenching is assessed as **Low**.

6.6.7.3 **Vessels:** OSPAR (2009) summarises general characteristics of commercial vessel noise. Vessel noise is continuous, and is dominated by sounds from propellers, thrusters and various rotating machinery (e.g. power generation, pumps). In general, support and supply vessels (50-100 m) are expected to have broadband source levels in the range 165-180 dB re 1μPa, with the majority of energy below 1 kHz (OSPAR, 2009). Large commercial vessels (>100 m) produce relatively loud, and predominately low frequency sounds, with the strongest energy concentrated below several hundred Hz. For most marine mammal species considered here, the hearing sensitivity below 1 kHz is relatively poor and, thus, it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of marine mammals to PTS from vessels is assessed as **Low**.

6.6.7.4 **Cable laying:** Underwater noise generated during cable installation is generally considered to have a low potential for impacts to marine mammals due to the non-impulsive nature of the noise generated, and the fact that any generated noise is likely to be dominated by the vessel from which installation is taking place (Genesis, 2011). As detailed above, the sensitivity of marine mammals to PTS from vessel noise is assessed as **Low**.

6.6.7.5 **Drilling:** The continuous sound produced by drilling has been likened to that produced by dredging activity; low frequency noise caused by rotating machinery (Greene, 1987). Recordings of drilling at the North Hoyle offshore windfarm suggest that the sound produced has a fundamental frequency at 125 Hz (Nedwell *et al.*, 2003). For most marine mammal species considered here, the hearing sensitivity below 1 kHz is relatively poor and, thus, it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of marine mammals to PTS from vessels is assessed as **Low**.

6.6.7.6 **Sheet piling:** The sensitivity of marine mammals to sheet piling is assumed to be the same as for impact piling.

6.6.7.7 **General:** MMO (2015) provides information on the acoustic properties of anthropogenic continuous noise sources; this includes noise sources such as dredging, drilling and shipping. For all three activities, the main energy is listed as being <1 kHz. For most marine mammal species considered here, the hearing sensitivity below 1 kHz is relatively poor and, thus, it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of marine mammals to PTS from these low frequency, continuous noise sources is assessed as **Low**.

Magnitude

6.6.7.8 The magnitude of impact of non-piling construction noise under the maximum design scenario is judged to be **Negligible**. These noise sources will have a local spatial extent, short-term duration, and are intermittent, meaning that, with the most precautionary estimates, a marine mammal would have to remain within close proximity (<820 m), for a 24-hour period, for PTS-onset to occur, which is extremely unlikely.

Significance

6.6.7.9 There is no significant impact to any marine mammal species for PTS from other construction activities (Table 6-11).

Table 6-11: Conclusion for the impact of PTS from other construction activities.

Species	Sensitivity	Magnitude	Significance
Common dolphin	Medium	Negligible	Minor (not significant)
Bottlenose dolphin	Medium	Negligible	Minor (not significant)
Risso’s dolphin	Medium	Negligible	Minor (not significant)
Harbour porpoise	Low	Negligible	Negligible (not significant)
Minke whale	Low	Negligible	Negligible (not significant)
Grey seal	Low	Negligible	Negligible (not significant)

6.6.8 Disturbance from Other Construction Activities (Continuous Noise Sources)

6.6.8.1 There is little evidence on the impact of disturbance of marine mammals from other offshore construction activities (e.g. rock placement, cable laying, trenching, etc.).

Sensitivity

6.6.8.2 Information regarding the sensitivity of marine mammals to other construction activities is currently limited. Available studies focus primarily on disturbance from dredging, and confirmed behavioural responses have been observed in cetaceans. Pirotta *et al.* (2013) noted that bottlenose dolphin presence, in foraging areas of Aberdeen harbour, decreased as dredging intensity increased. Due to the consistently high presence of shipping activity all year round, the dolphins were considered to be habituated to high levels of vessel disturbance and, therefore, in this particular instance, Pirotta *et al.* (2013) concluded that the avoidance behaviour was a direct result of dredging activity. However, this distinction in the source of the disturbance reaction cannot always be determined. For example, Anderwald *et al.* (2013) observed minke whales off the coast of Ireland in an area of high vessel traffic during the installation of a gas pipeline, where dredging activity occurred. The data suggested that the avoidance response observed was likely attributed to the vessel presence, rather than the dredging and construction activities themselves. As the disturbance impact from other construction activities is closely associated with the disturbance from vessel presence required for the activity, it is difficult to determine the sensitivity specifically to disturbance from other construction activities in isolation (Todd *et al.*, 2015). Therefore, it is anticipated that the sensitivity of each species will be similar to that for vessel disturbance, and should be considered as **Low** for all cetacean species, and **Negligible** for grey seals.

Magnitude

6.6.8.3 **Vessels:** Recent evidence exists from passive acoustic monitoring at the Beatrice and Moray East wind farms, where the extent of observed porpoise displacement was up to 4 km from non-piling construction vessel activity (Benhemma-Le Gall *et al.*, 2021). This is of **Low** magnitude: short-term and temporary behavioural effects in a small proportion of the population (given the limited impact range). Reproductive rates of individuals may be impacted in the short term (overall offshore construction activities max. 8 months, <1 breeding cycle).

6.6.8.4 **Dredging:** Table 12.25 in ES Volume 1 Chapter 12: Marine Mammals, presents the limited information available for dredging, and suggests that any potential displacement will be on a local scale (i.e. within 5 km), and limited to the duration of the activities and, therefore, unlikely to significantly affect marine mammal vital rates. This is of **Low** magnitude: short-term and temporary behavioural effects in a small proportion of the population (given the limited impact range). Reproductive rates of individuals may be impacted in the short term (overall offshore construction activities max. 8 months, <1 breeding cycle).

6.6.8.5 **Cable laying:** The Moray East assessment concluded that there were only limited disturbance impact ranges for cable laying being up to 220 m (Table 6-12). This is considered to be of **Negligible** magnitude: very short term, recoverable effect on the behaviour and/or distribution in a very small proportion of the population (given the very small impact ranges predicted).

6.6.8.6 **Trenching:** The Moray East assessment concluded that there were only limited disturbance impact ranges for trenching of 640 m (Table 6-12). This is considered to be of **Negligible** magnitude: very short term, recoverable effect on the behaviour and/or distribution in a very small proportion of the population (given the very small impact ranges predicted).

6.6.8.7 **Rock placement:** The Moray East assessment concluded that there were only limited disturbance impact ranges for rock placement of 550 m (Table 6-12). This is considered to be of **Negligible** magnitude: very short term, recoverable effect on the behaviour and/or distribution in a very small proportion of the population (given the very small impact ranges predicted).

6.6.8.8 **Drag embedment anchors:** There is no information available on the disturbance range from drag embedment anchors. In the total absence of any other data to present, TTS-onset can be used as a proxy for disturbance. TTS-onset for a stationary animal for drag embedment anchors (based on excavator scraping noise) is predicted to have a maximum impact range of 690 m for very high frequency cetaceans (Table 4-4, Volume 3, Technical Appendix 12.1: UWN Assessment). This is highly conservative, since it is expected that marine mammals would flee the area in response to the noise associated with drag embedment anchors and associated vessels. The Project Offshore Wind: underwater noise assessment states that the associated vessel noise is likely to be greater than that of the drag embedment anchoring activities themselves. This is considered to be of **Negligible** magnitude: very short term, recoverable effect on the behaviour and/or distribution in a very small proportion of the population (given the very small impact ranges predicted).

6.6.8.9 **Suction pile installation:** There is no information available on the disturbance range from suction pile installation. In the total absence of any other data to present, TTS-onset can be used as a proxy for disturbance. TTS-onset for a stationary animal for suction pile installation is predicted to have a maximum impact range of 5.6 km for very high frequency cetaceans (ES Volume 3, Technical Appendix 12.2 Underwater Noise Technical Report, Table 4-4). However, this is considered to be highly conservative, since it is expected that marine mammals would flee the area in response to the noise associated with suction pile installation and associated vessels. In fact, in a review by Koschinski and Luderann (2020), the noise from suction pumps could not be heard above background noise at Borkum Riffgrund 2 (137 dB at 750 m). This is of **Low** magnitude: short-term and temporary behavioural effects in a small proportion of the population (given the limited impact range). Reproductive rates of individuals may be impacted in the short term (overall offshore construction activities max. 8 months, <1 breeding cycle).

6.6.8.10 **Sheet piling:** According to the Blue Gem Wind engineers, cofferdam installation by sheet pile will require hammer energies between 5 and 300 kJ, of which, they estimate that only 30-50% of the energy is transferred into the sheet pile (information provided in the Project Design Envelope). Thus, the expected disturbance range is expected to be significantly less than that from impact pile driving of the anchors (800 kJ). Thus, the impact expected to be, at most, **Low** magnitude (as per pile driven anchors).

6.6.8.11 **Drilling:** There is a lack of data on disturbance ranges from drilling. Using the Level B harassment threshold[10] (NMFS, 2005), the Brims Tidal Project estimated that disturbance ranges for marine mammals from drilled piles would be up to 375 m[11]. The Navitus Bay Wind Park Environmental Statement[12] used the 90 dBht (*Species*) threshold for strong avoidance and predicted low impact ranges from drilling activities (<10 m for porpoise, dolphins and seals). This is of **Low** magnitude: short-term and temporary behavioural effects in a small proportion of the population (given the limited impact range). Reproductive rates of individuals may be impacted in the short term (overall offshore construction activities max. 8 months, <1 breeding cycle).

6.6.8.12 While there is a lack of data on the responses of marine mammals to other construction noise (such as dredging, trenching, cable laying etc.), previous modelling suggests that any potential displacement as will be on a local scale (i.e. max. 5 km) and limited to the duration of the activities, and therefore unlikely to significantly affect marine mammal vital rates.

[10] 120 dB re 1 µPa (rms) for continuous noise.

[11] Brims Underwater Noise Assessment (2015), Underwater Noise Assessment Report, By: Xodus Group, Client: Client: SSE Renewables Developments (UK) Ltd, Document Number: L-100183-S00-REPT-001.

[12] Navitus Bay Wind Park Environmental Statement (2014), Volume B Offshore, Chapter 11 Marine Mammals and Megafauna.

Table 6-12: Predicted impact ranges (m) for disturbance from various construction activities – data obtained from the Moray East ES[13].

Activity	Minke whale		Dolphins		Porpoise		Seals	
	90 dBht[14]	75 dBht[15]	90 dBht	75 dBht	90 dBht	75 dBht	90 dBht	75 dBht
Cable laying	18	180	9	75	29	220	2	29
Rock placing	70	390	31	170	99	550	17	99
Trenching	59	390	81	350	140	640	12	87

Significance

6.6.8.13 There is no significant impact to any marine mammal species for disturbance from other construction activities (Table 6-13).

[13] Moray Offshore Renewables Ltd. Environmental Statement. Technical Appendix 7.3 A – Marine Mammals Environmental Impact Assessment (2012).
[14] 90 dBht(*Species*): defined by Nedwell et al. (2005) as a strong avoidance reaction by virtually all individuals. This is described as an “instinctive reaction” where animals will avoid the noise.
[15] 75 dBht(*Species*): defined by Nedwell et al. (2005) as mild behavioural avoidance.

Table 6-13: Conclusion for the impact of disturbance from other construction activities.

Activity	Magnitude	Cetaceans		Grey seals	
		Sensitivity	Significance	Sensitivity	Significance
Vessels	Low	Low	Minor	Negligible	Negligible
Dredging	Low	Low	Minor	Negligible	Negligible
Cable laying	Negligible	Low	Negligible	Negligible	Negligible
Trenching	Low	Low	Minor	Negligible	Negligible
Rock placement	Negligible	Low	Negligible	Negligible	Negligible
Drag embedment anchors	Negligible	Low	Negligible	Negligible	Negligible
Suction pile	Low	Low	Minor	Negligible	Negligible
Sheet piling	Low	Low	Minor	Negligible	Negligible
Drilling	Low	Low	Minor	Negligible	Negligible

6.6.9 Barrier Effects

6.6.9.1 ***Synopsis of comments received:*** *NRW Advisory considers the magnitude of barrier effect impacts to be negligible in light of the definitions in Table 12.6. Given NRW Advisory considers the magnitude of barrier effect impacts to be negligible, the maximum significance score possible is Minor (adverse), which is not significant in EIA terms.*

Sensitivity

6.6.9.2 The Applicant acknowledges that there is little information available on the sensitivity of marine mammals to barrier effects. It is assumed that the sensitivity of marine mammals to a perceived small-scale barrier is **Negligible**, whereby individuals are expected to adapt their behaviour through small scale changes in movement pathways, such that the perceived barrier is unlikely to result in any changes to vital rates.

Magnitude

6.6.9.3 As stated in ES Volume 1 Chapter 12: Marine Mammals, section 12.6.3.5: There is no information available on the potential for floating WTG sub-structures to result in barrier effects for marine mammals. However, given the relative spatial scale of devices, the low number of devices at the Project, the water depth and the size of marine mammals, it is expected that marine mammals would be unlikely to perceive the Project substructures as a barrier to movement. The magnitude of the impact has been assessed as **Negligible**. In their comments, NRW Advisory agree with this magnitude assessment.

Significance

6.6.9.4 Therefore, the impact of perceived barrier effects from a small-scale Project such as The Project is considered to be of **Negligible** significance, which is not significant in EIA terms.

6.6.10 Seal Haul-outs

6.6.10.1 ***Synopsis of comments received:*** *Given that, at sufficient proximity, vessel activity can result in flushing seals from the beach and other responses which pose the risk of energetic costs for both adult seals and pups, NRW Advisory considers '**Low**' to be a more appropriate sensitivity for seals at haul out sites than 'negligible'.*

Sensitivity

6.6.10.2 The Applicant is content to increase the sensitivity of seals to disturbance at haul-outs from **Negligible** to **Low**, in line with NRW Advisory's recommendations.

Magnitude

6.6.10.3 As detailed in ES Volume 1 Chapter 12: Marine Mammals Disturbance at seal haul-outs (12.6.2.124 *et seq*.), the magnitude is considered to be **Negligible**.

Significance

6.6.10.4 Therefore, the sensitivity of grey seals to disturbance from haul-out sites is **Low**, and given the **Negligible** magnitude, the resulting impact significance remains **Negligible**, which is not significant in EIA terms.

6.7 Cumulative Effects Assessment

6.7.1 Negligible Impact Pathways

6.7.1.1 ***Synopsis of comments received:*** *effects "assessed as having a negligible effect significance during the Project assessment" were scoped out of the CEA. The intention of a cumulative assessment is to rule out the possibility of pathways which are negligible alone resulting in greater impacts cumulatively. Information should be provided to support this approach, or an alternative approach taken.*

6.7.1.2 In the sections below, the Applicant has provided additional information to support the approach taken, including: (i) additional justification for scoping out certain impact pathways from CEA; (ii) updates to quantitative elements of the CEA to account for changes to the Project-alone assessment (i.e. common dolphin disturbance due from pile driving); and, (iii) further consideration of some impact pathways scoped out of CEA and justification for the conclusions drawn.

PTS from Underwater Noise

6.7.1.3 The Applicant maintains that PTS from all construction activities should remain scoped out of the cumulative effects assessment. Since it is an offence to injure any EPS, it is expected that all offshore Projects that have the potential to cause PTS from construction activities will be required to implement an MMMP (for all explosive/piling/seismic activities), or will be required to ensure no risk of injury to EPS. Thus, this impact pathway is considered to be fully mitigated by each Project, and it is expected that the resulting risk is therefore negligible.

Disturbance from Pile Driving

6.7.1.4 The Applicant acknowledges that there is considerable uncertainty regarding the common dolphin density estimate. If the site-specific density estimate of 1.61 dolphins/km^2 is assumed throughout the impact range for pile driving disturbance, then this results in predicted impact to 7,919 dolphins (7.7% MU). The CEA has been updated to include this worst-case scenario prediction (Table 6-14). The worst-case scenario predicts that piling occurs concurrently with Rampion 2 in 2026, resulting in a total of 8,425 dolphins disturbed per piling day (8.2% MU). Despite the fact that this scenario assumes that >5% of the MU is predicted to experience repeated disturbance, the very short-term duration of the impact at The Project (piling over a maximum of 18 days) means that the magnitude of impact remains assessed as a **Low**, where short-term and/or intermittent and temporary behavioural effects are expected in a small proportion of the population, any impact to vital rates of individuals may occur only in the short term (over a limited number of breeding cycles, <1 in this case), and where any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered. As outlined in ES Volume 1 Chapter 12: Marine Mammals, paragraphs 12.6.2.47 *et seq*., the use of the harbour porpoise dose-response curve to predict common dolphin disturbance is highly conservative.

6.7.1.5 Common dolphins have been assessed as having a low sensitivity to disturbance from piling (and the same has been assumed for other construction-related activities). Therefore, disturbance from the cumulative impact of construction work across Projects located within the relevant MU, both prior to and during the construction of the Project, is concluded to result in a **Minor** effect, which is not significant in EIA terms.

Table 6-14: Cumulative effects assessment of disturbance from construction activities for common dolphins.

Project	Type	Tier	2026			
			Q1	Q2	Q3	Q4
Erebus	WTG Float	-	0	7,919	7,919	7,919
Bombora	Wave	1	0	0	0	0
TwinHub	WTG Float	1	0	0	0	0
AMETS	WTG Float	1	0	0	0	0
Greenlink	Interconnector	1	0	0	0	0
Rampion 2	WTG Fixed	4	506	506	506	506
TOTAL	**# impacted**		**506**	**8,425**	**8,425**	**8,425**
	% MU		**0.5%**	**8.2%**	**8.2%**	**8.2%**
	Magnitude		**N**	**L**	**L**	**L**

Disturbance from Other Construction Activities

6.7.1.6 ES Volume 1 Chapter 12: Marine Mammals, section 12.10: Cumulative Effects Assessment, focuses on disturbance effects from construction activities for all relevant offshore Projects. The approach to this assessment was to assume potential disturbance impact throughout the entire offshore construction period for each Project. Thus, this assumes a highly unrealistic case where offshore piling activities take place throughout the entire offshore construction window, and thus in some cases, extends over several years. In reality, the piling window will be only a small portion of the overall offshore construction window. The underwater noise disturbance impacts from other construction activities will also be ongoing throughout the offshore construction window, but these are expected to impact fewer individuals than impact pile driving. Therefore, the impact of disturbance from underwater noise from other construction related activities is essentially already included within the CEA, as they will be less than those presented for piling impacts.

Vessel Impacts

6.7.1.7 It is expected that all offshore Projects will be required to either implement a VMP or follow best codes of conduct with regards to manging a vessel in the presence of marine mammals to minimise the risk of collisions. Thus, it is expected that the magnitude of risk of vessel collisions at all offshore Projects is **Negligible**. The sensitivity of marine mammals is **High** (since there is a risk of mortality resulting from collisions), the magnitude of the impact is expected to be negligible and thus the impact of collisions from vessels cumulatively across all offshore Projects is assessed as **Minor adverse**, which is not significant in EIA terms.

6.7.1.8 The cumulative risk of disturbance from vessels is already provided in ES Volume 1 Chapter 12: Marine Mammals section 12.10.6: Cumulative disturbance from vessels.

Impacts on Prey

6.7.1.9 ES Chapter 10: Fish and Shellfish Ecology concluded that there would be no significant effect to fish and shellfish in the cumulative effects assessment:

- Construction: temporary habitat disturbance/damage = the cumulative effect is considered minor adverse, which is not significant in EIA terms;
- Construction: Increased suspended sediment and sediment deposition = no cumulative effect is predicted, which is not significant in EIA terms;
- Construction: Disturbance, injury and mortality from subsea noise = the cumulative effect is considered minor adverse, which is not significant in EIA terms;
- O&M: Long-term loss of habitat via Project infrastructure = the cumulative effect is considered minor adverse, which is not significant in EIA terms;
- O&M: temporary habitat disturbance via repair and remediation works = the cumulative effect is considered minor adverse, which is not significant in EIA terms;
- O&M: Increased suspended sediment and sediment deposition via repair and remediation works = the cumulative effect is considered minor adverse, which is not significant in EIA terms;
- O&M: Fish aggregating device and collision effects = the cumulative effect is considered minor adverse, which is not significant in EIA terms;

- O&M: Reduced fishing pressures within the Project area = the cumulative effect is considered minor beneficial, which is not significant in EIA terms;
- O&M: Electromagnetic Frequency effects from cables = the cumulative effect is considered minor adverse, which is not significant in EIA terms;
- O&M: Disturbance, injury and mortality from subsea noise produced via operational activities = the cumulative effect is considered minor adverse, which is not significant in EIA terms; and
- Decommissioning = the cumulative effect is considered minor adverse, which is not significant in EIA terms.

6.7.1.10 Therefore, it follows that there will be no significant impact to marine mammals. At most, there may be a **Low** magnitude of impact from cumulative impacts on prey species.

6.7.1.11 While there may be certain species that comprise the main part of their diet, all marine mammals (except Risso's dolphins) in this assessment are generalist feeders, and are thus not reliant on a single prey species. They are therefore assessed as having a **Low** sensitivity to changes in prey abundance and distribution. Given that Risso's dolphins have a more specialised diet, they are precautionarily considered to have a **Medium** sensitivity to changes in prey abundance and distribution (see section 6.5 above). Therefore, the cumulative effect on indirect impacts on prey species for all marine mammals considered here is **minor adverse**, which is not significant in EIA terms.

Barrier Effects

6.7.1.12 The impact of underwater noise resulting in a barrier to animal movement is already covered under PTS and disturbance from underwater noise. This section summarises the potential for the physical presence of structures underwater being perceived by marine mammals as a barrier to movement.

6.7.1.13 It is expected that there will be no barrier effects from any fixed foundation OWF Projects, since there is evidence that marine mammals actively use and are detected within operational array areas (e.g. Rose *et al.*, 2014, Russell *et al.*, 2014). Since the potential for barrier effects from floating OWFs is currently unknown, there is the potential for cumulative impacts with other floating OWFs, however the likelihood of this is unknown. Given the relative spatial scale of the floating OWF Projects screened into the CEA (Erebus = 10 platforms, TwinHub = 2 platforms, AMETS = 1 platform), it is expected that marine mammals would be unlikely to perceive these substructures as a barrier to movement. Likewise, there is the potential for marine mammals to perceive the physical presence of wave and tidal devices as barriers to movement. Studies conducted, to date, have shown no evidence of barrier effects on seals from tidal turbines (SeaGen), though data suggest there may be some local avoidance (Sparling *et al.*, 2017). There is also evidence of avoidance of tidal turbines (MeyGen) by harbour porpoise, though this avoidance is very local scale (Gillespie *et al.*, 2021, Palmer *et al.*, 2021). However, these studies were conducted on single or small-scale arrays, and the potential for barrier effects from future large commercial scale arrays of several tens or hundreds of turbines is currently unknown.

6.7.1.14 The Applicant acknowledges that there is little information available on the sensitivity of marine mammals to barrier effects. It is assumed that the sensitivity of marine mammals to a perceived small-scale barrier is **Negligible**, whereby individuals are expected to adapt their behaviour through small scale changes in movement pathways such that the perceived barrier is unlikely to result in any changes to vital rates. The magnitude of impact from the small-scale floating wind, wave and tidal arrays considered here is expected to be **Low**, at most, as it is expected that any impact would not result in changes to vital rates at a level sufficient to result in population level consequences. Therefore, the cumulative effect of barrier effects for all marine mammals considered here is **Negligible**, which is not significant in EIA terms.

6.8 Inter-related Effects

6.8.1.1 As described throughout the assessment, aspects of offshore windfarm construction, operation, and decommissioning, that marine mammals may be sensitive to, include underwater noise causing potential physical and auditory injury or behavioural changes and displacement/barrier effects (preventing movement of animals), as well as behavioural changes or disturbance from other Project activities, collision risk with vessels, changes to prey availability, and entanglement in sub-sea structures.

6.8.1.2 Inter-related effects include both effects from exposure to a single stressor from multiple sources (e.g. underwater noise from piling, UXO, and vessels) and effects from exposure to multiple stressors from single or multiple sources over a defined period or construction phase (e.g. underwater noise and effects on prey from vessel activity, and piling during construction). When stressors act through a common pathway, this provides a high potential for interaction (synergistic or antagonistic) because the stressors may provoke similar responses and therefore exacerbate the impacts (National Academies of Sciences Engineering and Medicine, 2017).

6.8.1.3 In this section all impacts with the potential to interact with each other are considered and assessed. Interaction of impacts are considered both within a development phase as well as across development phases (i.e. over the Project lifetime). Such inter-related effects include both:

- Project lifetime effects: i.e. those arising throughout more than one phase of the Project (construction, operation, and decommissioning) to interact and potentially create a more significant effect on a receptor than if just one phase were assessed in isolation; and
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor (or group). Receptor-led effects might be short term, temporary or transient effects, or incorporate longer term effects.

6.8.1.4 Firstly, the impacts are considered within a development phase (i.e. construction, operation or decommissioning) to see if, for example, multiple construction impacts could combine. Secondly, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across development phases. The significance of each individual impact is determined by the sensitivity of the receptor and the magnitude of effect. When considering interactions, we assume the sensitivity is constant whereas the magnitude may differ. Therefore, when considering the potential for impacts to be additive it is the magnitude of effect which is important.

6.8.2 Construction

6.8.2.1 During the construction phase there is a high potential for synergistic interactions of injury and disturbance impacts. For example, disturbance from UXO followed by disturbance from piling activity increases the overall number of days of disturbance and, therefore, may increase the magnitude of the impact as well. However, the key component here is the temporal nature of the interaction which is relatively short term for The Project (one single UXO detonation, and 18 days piling). Additionally, the MMMP (for both UXO clearance and piling) will reduce the risk of injury to negligible levels, and therefore limit this interaction pathway. Therefore, no increases in magnitude or significance of the impacts assessed alone are anticipated for any of the injury or disturbance impacts. There is a potential interaction between all disturbance and injury impacts, with indirect impacts on prey. However, as there are no significant impacts to fish species predicted during construction alone (ES Volume 1 Chapter 10: Fish and Shellfish Ecology) and several of the disturbance impacts or mitigation measures result in marine mammals leaving the immediate development area, no increase in magnitude, or hence significance, for this interaction pathway is warranted. Likewise, for vessel collision interaction pathways with other impacts, there is no interaction pathway if marine mammals are expected to experience temporary and local scale displacement from the construction area.

6.8.3 Operation

6.8.3.1 During the O&M phase, potential interactions between barrier effects, disturbance from vessels, disturbance at seal haul outs, indirect impacts on prey and entanglements in sub-sea structures were considered. The potential for synergistic interactions is highest through common pathways (e.g. disturbance). However, given the relatively small spatial footprint of any disturbances during O&M, along with the episodic nature of the impacts, it is not considered that there would be an increase in the magnitude or significance level for these interactions. The impacts from barrier effects and entanglement are mutually exclusive (no risk of entanglement from an area that is not being used) therefore there is no increase in magnitude or significance level for these interactions, compared with their significance alone. There is a potential interaction between disturbance impacts and indirect impacts on prey. However, as there are no significant impacts to fish species predicted during operations alone (ES Volume 1 Chapter 10: Fish and Shellfish Ecology), and several of the disturbance impacts might result in marine mammals being displaced on a very local scale within the array area, no increase in magnitude, or significance level, for this interaction pathway is warranted.

6.8.4 Decommissioning

6.8.4.1 Impacts and potential interaction pathways are anticipated to be similar to, or less than, construction following the decommissioning plan.

6.8.5 Lifetime and receptor-led

6.8.5.1 Injury and disturbance impacts from underwater noise sources are anticipated to be of the greatest magnitude (not withstanding mitigation measures) during the relatively short-term construction (UXO clearance, piling, other construction activities and vessels) and decommissioning phases (vessels, cutting of structures etc.), which are separated by the longer-term operation phase, with relatively small scale and episodic impacts. As there is no evidence of long-term displacement of marine mammals from operational windfarms, over the Project lifetime these impacts are not considered to combine via any pathway that would represent an increase in the significance level for any of the receptors.

Chapter 7 Shipping and Navigation

7.1 Introduction

7.1.1.1 The following sections sets out the response to the Chamber of Shipping (CoS) comments, dated 18 March 2022, on shipping and navigation. Responses to all other shipping and navigation stakeholders are presented in the Consultation Response spreadsheet.

7.2 Use of Accident Data

7.2.1.1 10 years of Marine Accident Investigation Branch (MAIB) historical data was utilised in the Navigational Risk Assessment (NRA) to ensure recency of the incidents to existing navigational practices, technology and waterway geometry - also drawing upon incident datasets from other sources. Where useful for the purposes of the NRA, reference to other historical incidents that are geographically relevant (such as the Sea Empress) lying outside the 2010-2020 MAIB dataset was made. Given the relative scarcity of Offshore Wind Farm (OWF) industry related incidents, a wider review of the UK experiences on other Projects was also conducted.

7.2.1.2 The Applicant notes the CoS comments regarding a longer term dataset (which has subsequently been received from the MAIB), an updated analysis of which is provided below, and in Figure 7-1 to Figure 7-3. These do not show a substantial difference in accident frequency near to the array area, with three additional incidents accounted for by mechanical failures aboard fishing vessels. Near to cable landfall, the number of MAIB reported accidents has declined since 2010. We believe that the results of this supplementary analysis do not substantially change the conclusions of the NRA and therefore the statement on navigation safety of the Project.

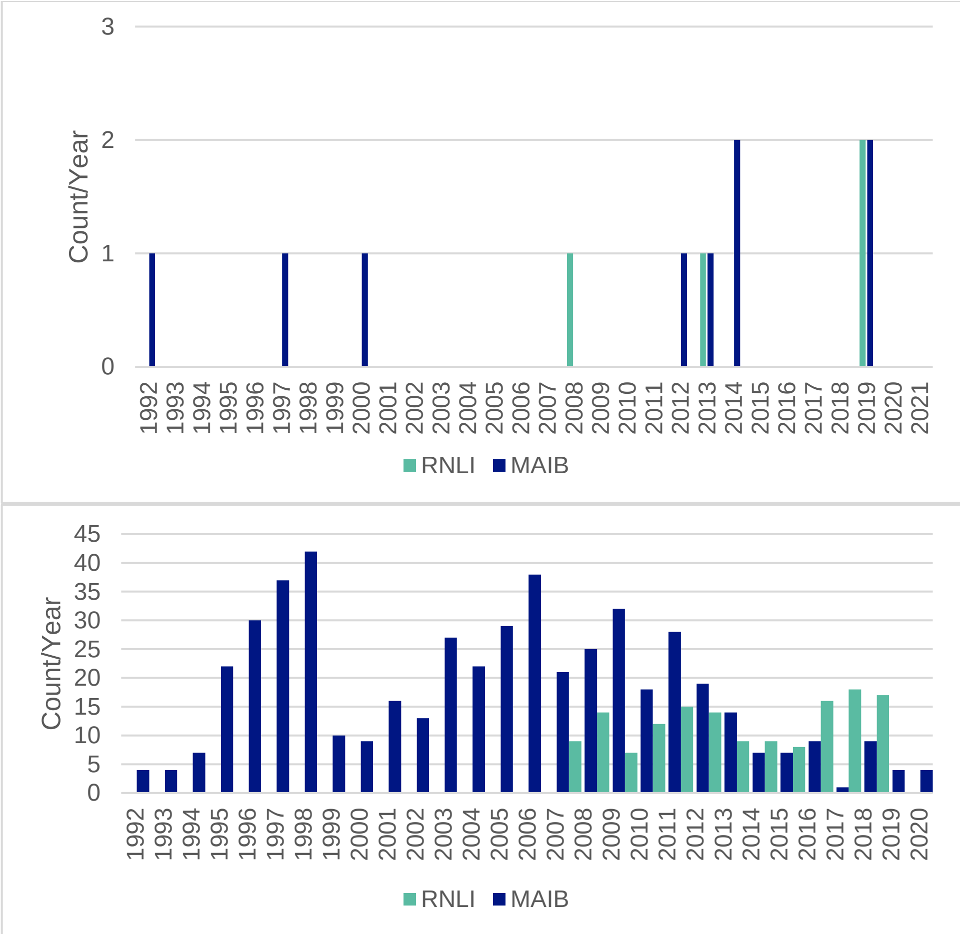


Figure 7-1: Historical incident analysis (extended to 1992-2021) (top= Array Area plus 10km, bottom=Cable Corridor plus 10km).

7.3 Anchoring and Loitering

7.3.1.1 Within the NRA the vessel traffic data was reviewed and analysed across a range of speeds. Through this analysis and also with consultation, tankers were identified as often loitering at slow speed or stopped to the south-west of Milford Haven Port Authority (MHPA) and near to the project site. 8 knots was identified as a relevant threshold by comparing in-transit vessel speeds against those of interest in the project vessel traffic datasets (and as presented in Figures 69 and 70 in the NRA).

7.3.1.2 Whilst the CoS have suggested that a lower speed threshold should be utilised, sensitivity analysis undertaken by NASH Maritime with lower thresholds did not meaningfully alter the interpretation of these activities. Given the risk profile associated with loitering vessels, it is considered that the choice of a higher speed threshold of 8kts is more conservative and precautionary than a lower limit. Figure 7-4 to Figure 7-7 provide a breakdown by a range of speeds less than 8 kts, to show findings from additional analysis.

7.4 Cumulative Impacts

7.4.1.1 The Project approach to cumulative was agreed with NRW Advisory/JNCC, that sufficient information on other proposed Projects was necessary to conduct the Cumulative Impact Assessment (CIA). It is not certain whether any further Projects will progress, and if so in what form, and are subject to additional data collection and planning by their respective developers. Therefore, in accordance with best practice, a qualitative high-level consideration of the cumulative impacts of these Projects was conducted.

7.4.1.2 In consistency with this approach and in accordance with MGN654, other guidance and policy, a cumulative assessment was undertaken within the NRA to determine the significance of navigational impacts (such as routeing, collision and allision risk) of White Cross and other proposed Projects which had submitted Scoping. At the time of the NRA, only Project Valorous and the Pembrokeshire Demonstration Zone had submitted scoping reports and therefore, the analysis within the cumulative assessment was limited to this extent. Any future proposed Projects will necessarily have to complete a cumulative NRA to account for any changes in the status of these applications.

7.4.1.3 With respect to the CoS stated cumulative navigation concerns between The Project and Valorous: The third para in 8.11.3 primarily refers to the space between the Project and Valorous (2 nautical miles wide) and the analysis of the baseline, and our assessment of the future baseline, shows that this is not a route which is regularly transited. The low frequency of transit in this direction is the rationale for the statement "*... the likelihood of two vessels meeting here is not significant*").

7.4.1.4 With regards to the CoS comment on the use of language, the NRA notes that "*The cumulative effects are not considered to be significantly worse than the Project in isolation*." Whilst the language of "*worse*" could be clarified, the intent is to conclude that the cumulative impacts are not considered to be so meaningfully greater than the impacts in isolation, that they pose an unacceptable risk to navigation safety.

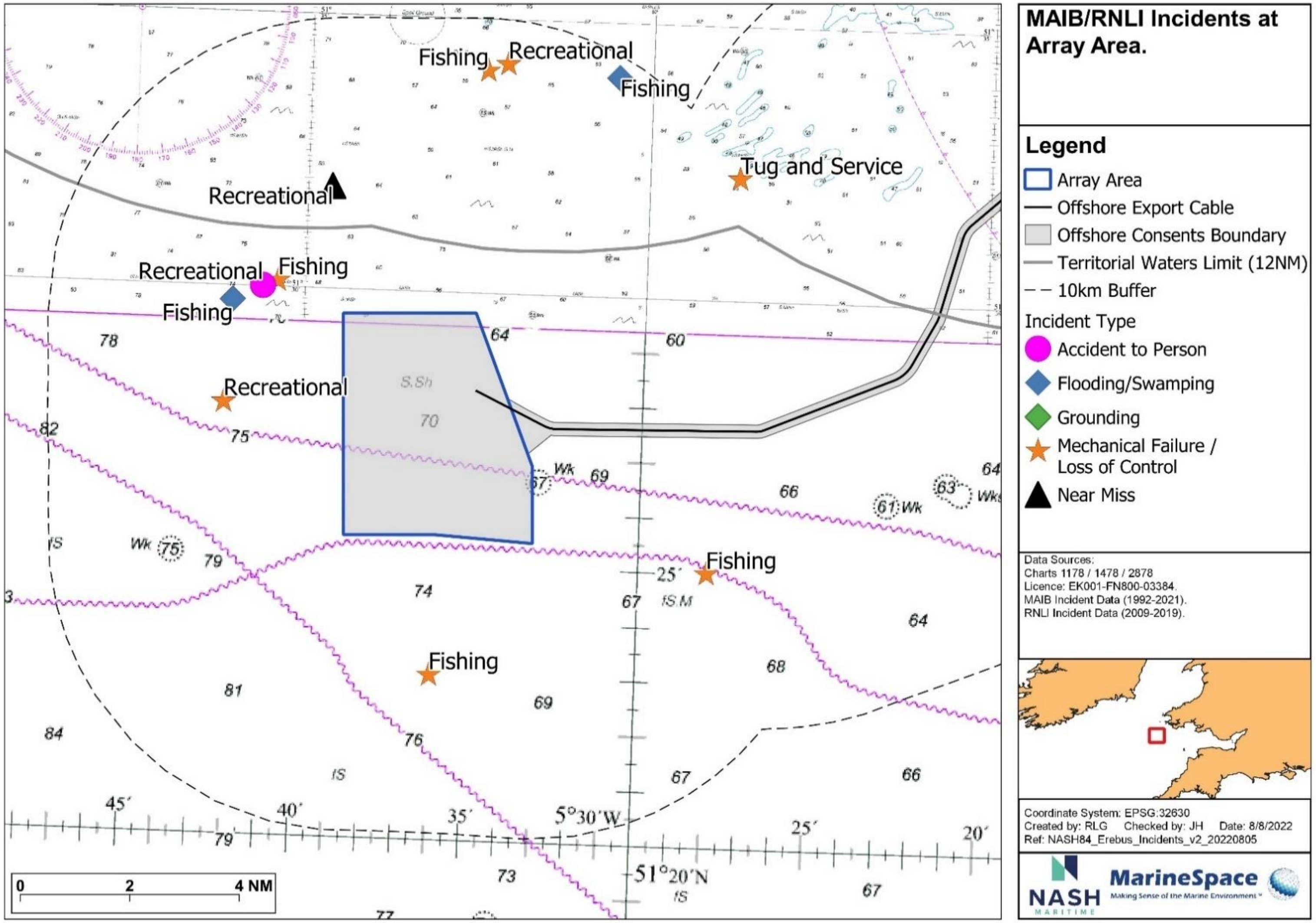


Figure 7-2: Historical incident data in array area (extended to 1992-2021).

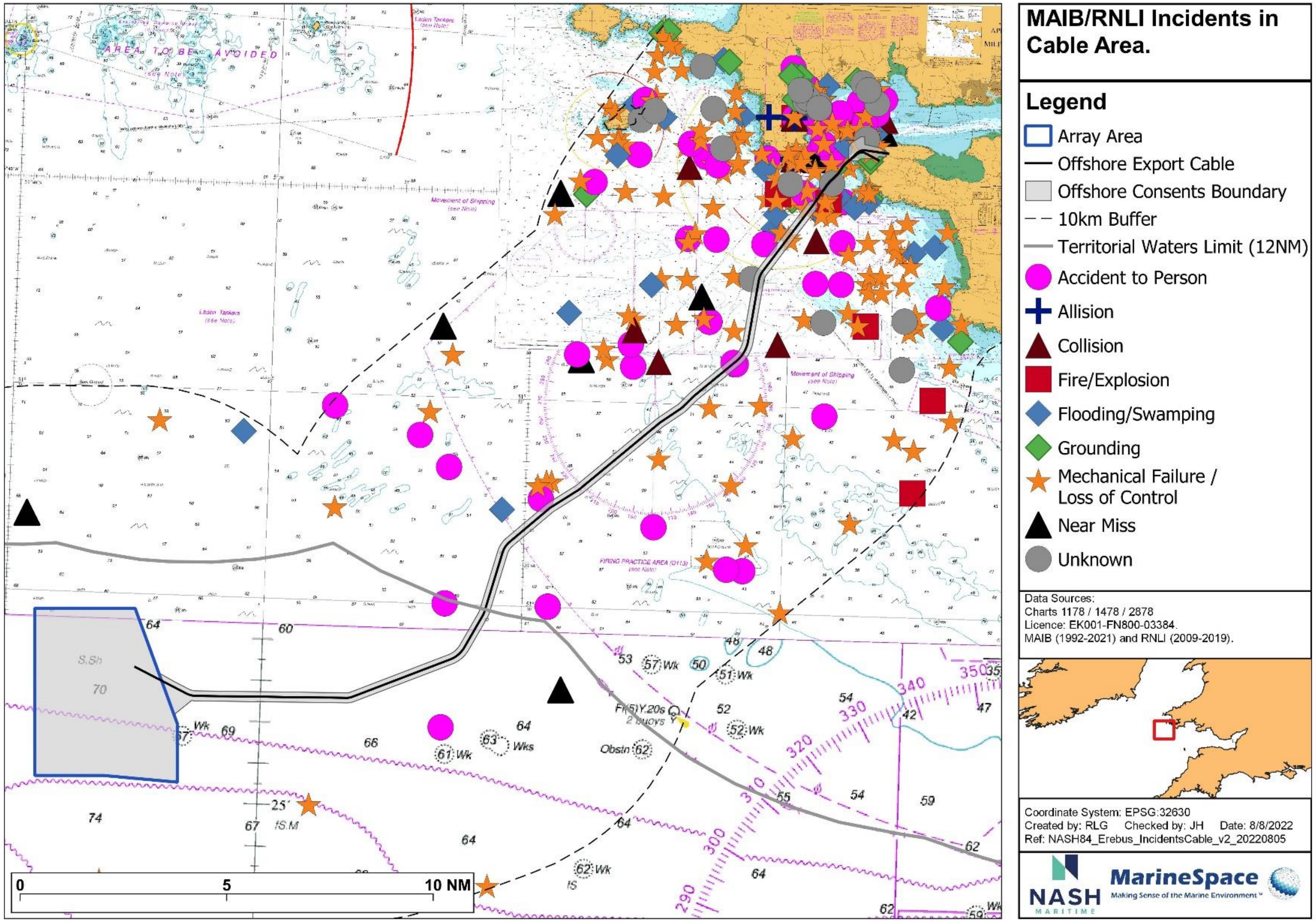


Figure 7-3: Historical incident data in cable corridor (extended to 1992-2021).

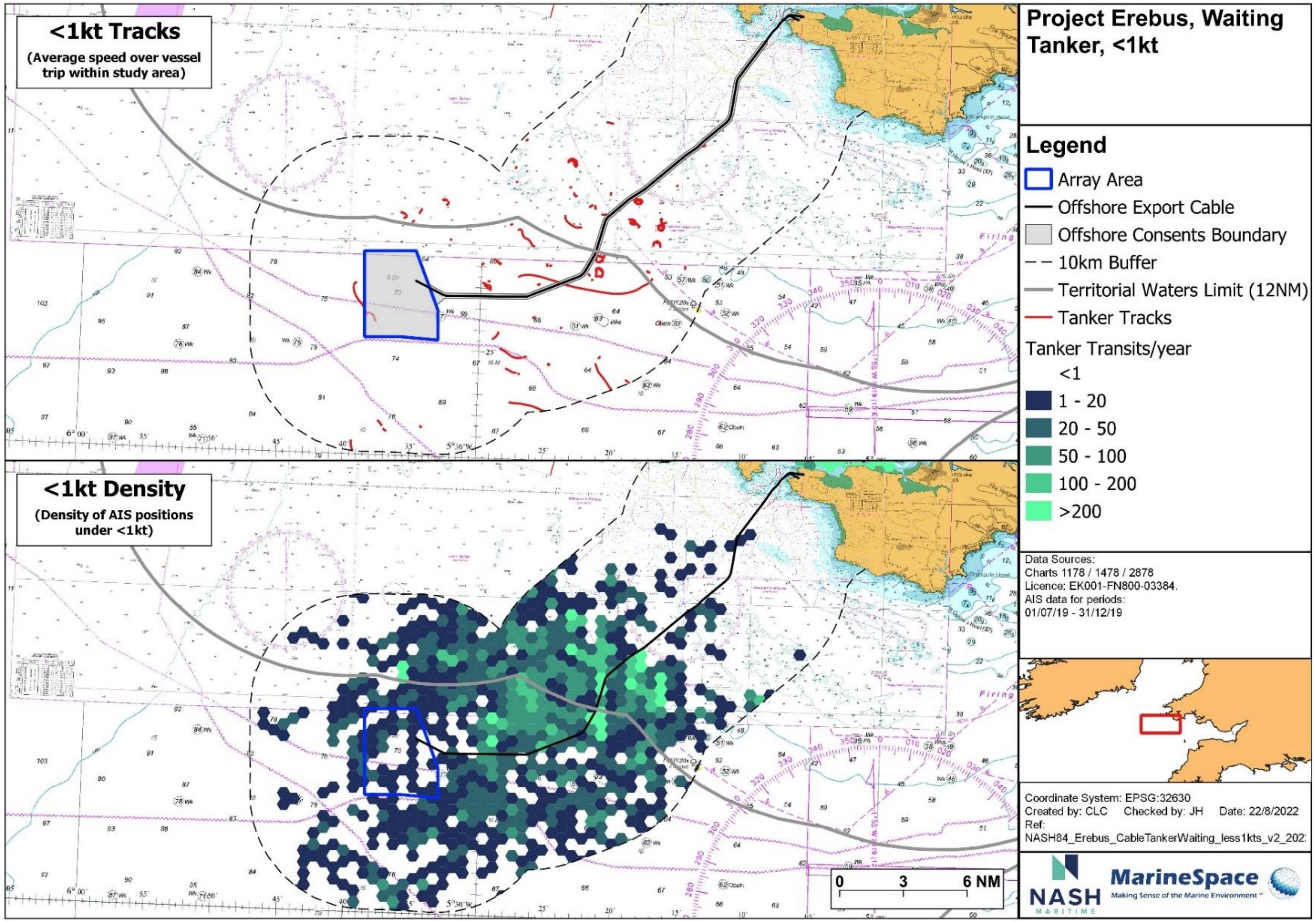


Figure 7-4: Analysis of tanker loitering at different speeds.

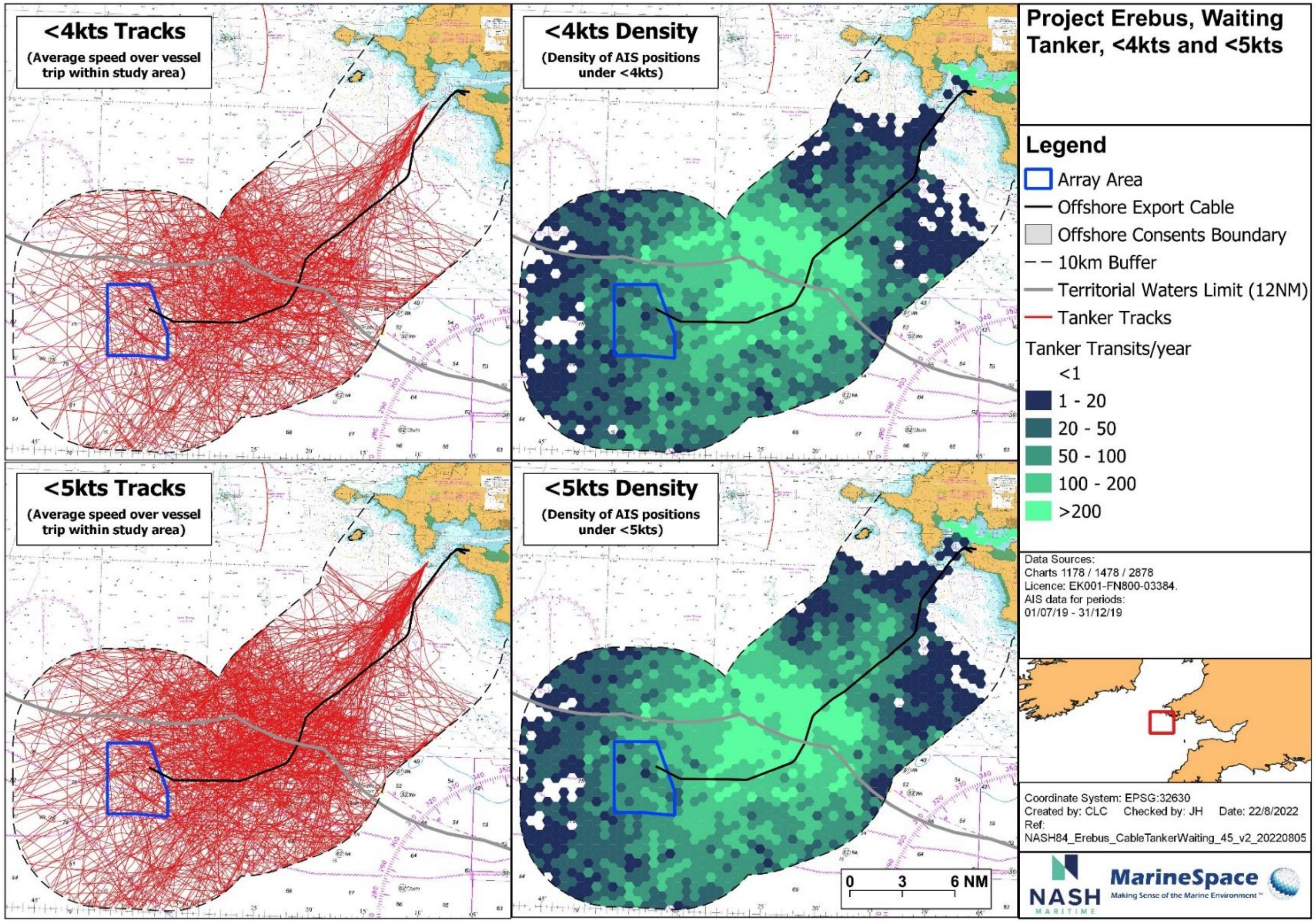


Figure 7-5: Analysis of tanker loitering at different speeds.

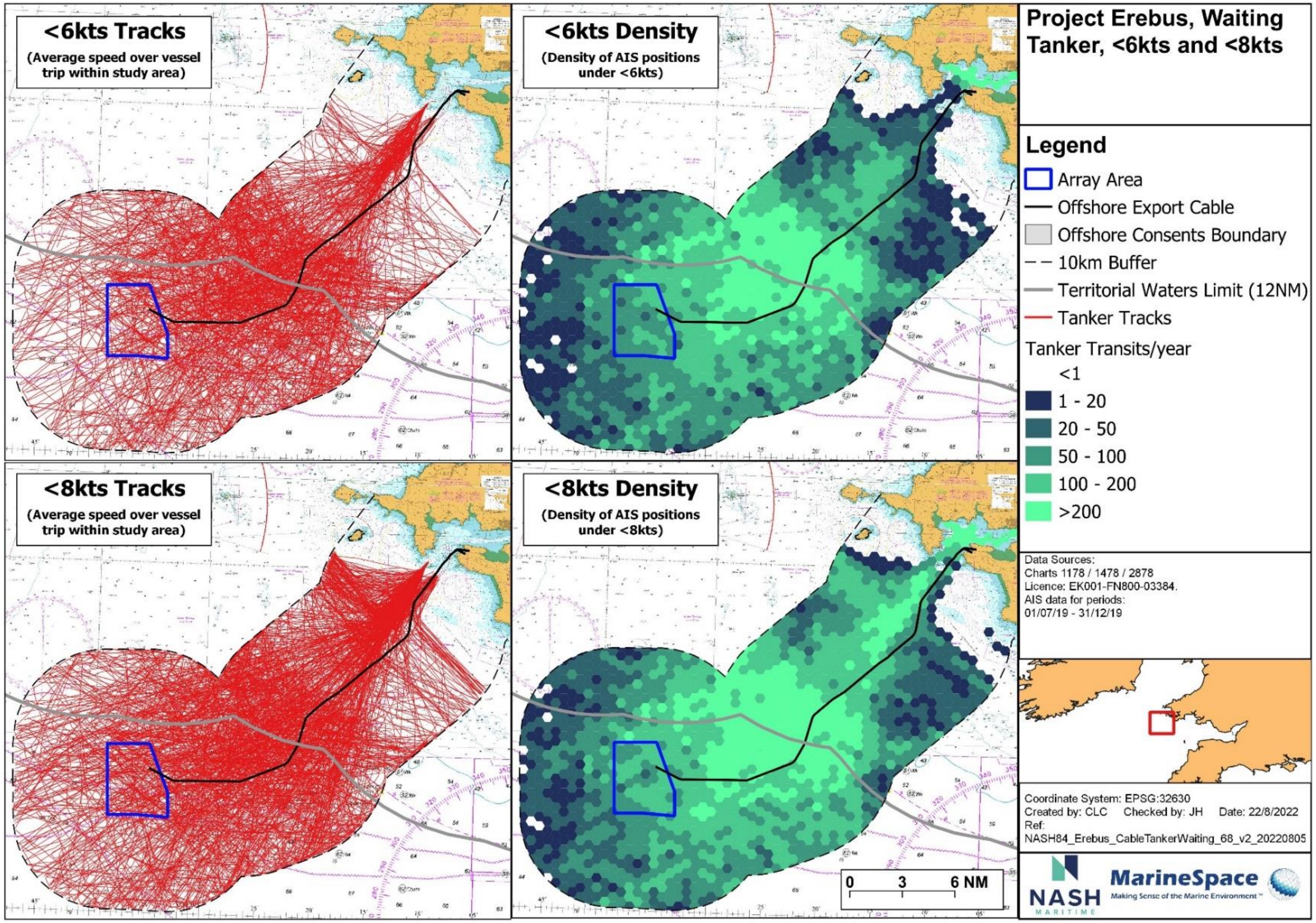


Figure 7-6: Analysis of tanker loitering at different speeds.

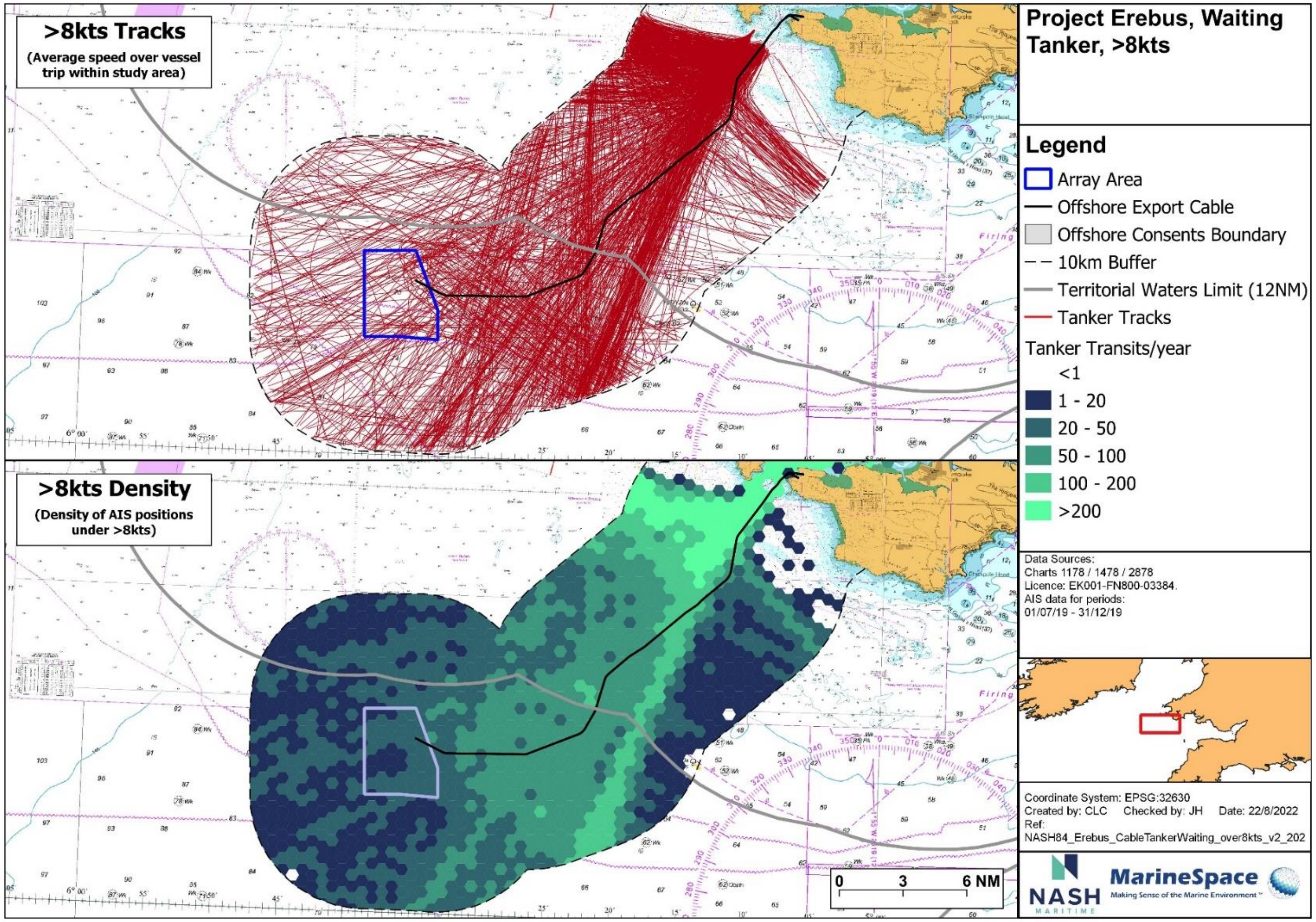


Figure 7-7: Analysis of tanker loitering at different speeds.

Chapter 8 Cumulative Effects

8.1 Project Inclusion

8.1.1.1 During consultation with NRW Advisory/JNCC it was agreed that Cumulative Impacts Assessment (CIA) should consider other proposed developments where there is sufficient information for their effects to be reasonably understood; and built and operational Projects where there are ongoing impacts. This aligns with the approach outlined in PINS Technical Advice Note 17 (PINS, 2012) and therefore complies with EIA requirements. It was clarified that Projects could only be included where adequate information was available within the public domain to allow a meaningful assessment, and where there was good reason for thinking the Projects would be taken forward. On this basis, it was established that certain known, but early stage, developments could not be assessed within CIA where there was insufficient detail for effects to be reasonably understood. This discussion was instigated following the announcement of the proposed two Llŷr Projects and the Whitecross Project. At this stage, it was agreed that if scoping reports were not submitted for these Projects by 01 October 2021 (email dated 07 September 2021, NRW Marine Licensing), they would not be included within the original ES. However, it was noted at the time, that where Projects come forward following the cut-off date, we understood that we may be requested to provide additional information during the determination period.

8.1.1.2 Although scoping reports have subsequently been submitted for these Projects, the lack of site-specific survey data, modelling outputs and details of turbine specifications and layout preclude assessment for the majority of topic areas with a reasonably degree of certainty. The potential for cumulative/in combination effects associated with these Projects will be assessed as part of the environmental assessment for those Project if, and when, they proceed to licence application stage. This determination would not affect the assessment of impacts associated with the Project, as any impacts/adverse effects associated with subsequent developments, will be addressed by those Projects at the time of their assessment.

8.1.1.3 The key point to bear in mind, with regards to inclusion and exclusion of these Projects, relates to certainty that the developments will progress. The Crown Estate's announcement of the upcoming leasing round for floating wind developments within the Celtic Sea means that, before any work may commence on the respective EIAs, it will be necessary to await the outcomes of this process. Specifically with respect to Valorous, should Blue Gem Wind be awarded the site in this leasing round, EIA will commence once TCE lease process has concluded. This additional uncertainty, related to who will progress their respective sites, is considered to provide further basis for exclusion from the CIA.

8.1.1.4 It should be noted that although assessment within the original EIA submission captured potential cumulative effects for the Project and Valorous for many receptor groups, it was not possible for other receptor groups, such as ornithology, where there was insufficient information available to allow any meaningful assessment. Cumulative assessment was completed where this could be determined without understanding of high-resolution site-specific baseline information and without specific information on likely turbine specifications and layout. However, the lack of such detailed Project-specific data precluded meaningful assessment of cumulative effects on ornithological receptors.

Chapter 9 HRA Screening Report

9.1 Ornithology

9.1.1 Migratory Bird Populations

9.1.1.1 Both JNCC and NRW Advisory noted in their responses that a threshold of 1% of population potentially interacting with the Project is not sufficient to conclude no Likely Significant Effect (LSE). JNCC noted that analysis is required to assess potential mortality, and this should be assessed against baseline mortality rate, to consider whether mortality rates are over 1% of baseline mortality. NRW Advisory clarified that this does not consider the status of a feature's SPA population against its conservation objectives. It was recognised within the Ornithology Technical Meeting (28 June 2022) that this objection does not necessarily mean that there will be adverse effects on site integrity, but that this should be concluded within the Report to Inform Appropriate Assessment (RIAA), rather than within the Screening Report.

9.1.1.2 It should be noted that within the AyM Migratory Collision Risk Modelling Report (RWE, 2022b) it is stated that:

> *"The standard threshold for migratory birds used is that the species will be screened in [to assessment for collision risk] if at least 1% of the UK population is expected to pass through the site footprint".*

9.1.1.3 As such, the approach adopted by the Applicant with respect to potential impacts on migratory bird species is considered consistent. However, the Applicant notes and accepts the comments from NRW Advisory and JNCC that this assessment should have been made during the RIAA rather than the HRA Screening Report.

9.1.1.4 The SOSSMAT tool was used in the HRA Screening Report to determine the number of migratory birds which may pass the Project site (i.e. where there is a potential for interaction). The tool outputs identified 21 migratory bird species where there was potential for interaction with the Project site (Table 9-1). It should be noted that all species identified were seabirds; no waders or wildfowl were listed in the tool outputs.

9.1.1.5 The result produced by the SOSSMAT tool was applied to the Biologically Defined Minimum Population Size (BDMPS) for respective species, to produce a number of birds that may pass the site during migration. Within the Screening Report this number was compared against UK and international population sizes to justify whether the pressure pathway should be screened in or out of assessment for each respective receptor species. All values were below the 1% of UK population threshold.

9.1.1.6 It is proposed that the approach taken for assessment of species-specific collision risk within the HRA Screening Report is also applied in this case, when considering potential impacts on birds during seasonal migration. Within the Screening Report, species were screened out with respect to collision risk if they were determined to be at low species-specific collision risk; this reduced the list to 13 species (Table 9-1). Of these 13 species, 3 were terns. As noted in the NRW Advisory response to the Project application, terns cannot be assessed with SOSSMAT, as they tend to migrate along the coast. As such, these species are not considered at risk to effects from turbine structures, and have not been emboldened irrespective of risk score. This process expresses the total species-specific risk score for each species, as reported in Furness *et al.* (2013), as a proportion of the highest scoring species (herring gull). Any species with a risk percentage ≤10% were screened out from further assessment.

Table 9-1: Bird species identified by SOSSMAT tool as potentially interacting with the Project Erebus site during seasonal migration. Species identified as being at potential risk of collision impacts are highlighted in bold.

Receptor Species	Collision Risk Index Score	Total Risk Score
Atlantic puffin *Fratercula arctica*	2.07	27
European storm petrel *Hydrobates pelagicus*	6.97	91
Lesser black-backed gull *Larus fuscus*	**73.51**	**960**
Manx shearwater *Puffinus puffinus*	0.00	0
Northern gannet *Morus bassanus*	**55.51**	**725**
Common guillemot *Uria aalge*	2.83	37
Northern fulmar *Fulmarus glacialis*	3.68	48
Razorbill *Alca torda*	2.45	32
Great skua *Stercorarius skua*	**24.50**	**320**
Black-headed gull *Chroicocephalus ridibundus*	**22.05**	**288**
Roseate tern *Sterna dougallii*	**13.40**	**175**
Common tern *Sterna hirundo**	17.53	229

Receptor Species	Collision Risk Index Score	Total Risk Score
Arctic tern *Sterna paradisaea**	15.16	198
Sandwich tern *Sterna sandvicensis**	18.76	245
Great cormorant *Phalacrocorax carbo*	7.89	103
Herring gull *Larus argentatus*	**100.00**	**1306**
Great black-backed gull *Larus marinus*	**93.80**	**1225**
Common gull *Larus canus*	**45.79**	**598**
European shag *Phalacrocorax aristotelis*	**11.49**	**150**
Red-throated diver *Gavia stellata*	**16.31**	**213**
Common scoter *Melanitta nigra*	7.35	96

**As noted in the NRW response to Project application, species cannot be assessed with SOSSMAT as they tend to migrate along the coast. As such, these species are not considered at risk to effects from turbine structures and have not been emboldened irrespective of risk score.*

9.1.1.7 Based on this information, it is determined that LSE cannot be concluded for the 10 species identified as being at collision risk from Project infrastructure in Table 9-1, and that these should be screened into assessment within the RIAA.

9.1.1.8 It is also proposed that the number of individual birds at risk is not sufficient to require additional collision risk modelling (i.e. <1% of UK population). As such, within the RIAA, no adverse effect on site integrity can be concluded for the relevant classified SPA populations from pressures associated with collision between migratory bird species and Project infrastructure.

9.1.2 Marine Mammals

9.1.2.1 NRW Advisory advised that Table 5.2 of ES Volume 3 Technical Appendix 8.2: Habitats Regulations Assessment Screening Report, did not provide justification for screening out 3 specific pressure pathways with respect to marine mammal receptors. The corresponding justification is provided in Table 9-2.

Table 9-2: Potential pressure pathways for marine mammal receptors during all Project phases

Project Phase	Effect	Justification
Construction/operation and maintenance and decommissioning	Introduction or spread of invasive non-native species (INNS)	The only pathway for adverse effects on marine mammal receptors from introduction and spread of INNS is through effects to prey availability. Given the highly mobile nature of marine mammals and the extensive distances they travel while foraging, it is expected that any changes to feeding resources from INNS introduction/spread will be negligible. **No LSE** is expected from this pressure for marine mammal receptors.
	Changes to physical processes	Changes to physical processes due to deployment of Project infrastructure may result in localised scour around these structures, due to changes in tidal currents and seabed morphology. Scour may, in turn, lead to a loss of sediment, which may directly impact the physical structure of the adjacent habitats and indirectly effect resident benthic communities. Marine mammals are highly mobile and forage over large distances, and across a range of different tidal conditions. As such, they are not considered sensitive to relatively minor changes in tidal currents. Although changes to physical processes may result in indirect effects to benthic communities, these effects are expected to be highly localised. The extent of these effects is expected to correspond with a negligible proportion of overall habitat available to these animals. As such, **No LSE** is expected from this pressure for marine mammal receptors.
	Electromagnetic field (EMF) disturbance	The Applicant is not aware of any data that suggest marine mammals are directly sensitive to EMF effects. These animals may be indirectly affected through changes to prey resources. However, EMF are limited to the immediate vicinity of electrical cables. As such effects will be highly localised around transmission assets and any effects that do occur will correspond with a negligible proportion of overall habitat available to these animals. As such, **No LSE** is expected from this pressure for marine mammal receptors.

Chapter 10 Report to Inform Appropriate Assessment (RIAA)

10.1 Benthic Ecology

10.1.1 Greenlink Interconnector Crossing

Overview

10.1.1.1 This section clarifies the total spatial footprint of rock protection that is proposed to be placed at the Greenlink interconnector cable crossing, which is located upon the Turbot Bank Annex I sandbank. These values are applied below, to provide an updated assessment on long-term habitat loss for this feature.

Footprint of Cable Rock Protection

10.1.1.2 The Applicant acknowledges that there was a discrepancy between the amount of cable protection presented in the ES and the RIAA.

10.1.1.3 For the ES, the values had been derived from the Project Design Envelope (PDE), where the total area was based on 120-150 m length, and 10-14 m width. This resulted in a worst-case, 150 x 14 m = **2,100 m²** (**0.0021 km²**).

10.1.1.4 For the RIAA, the values had been derived from the Seabed Intervention Sheet, where the footprint of rock was defined as **559.7 m²** (**0.00059 km²**). This was based on a length of 70 m, and width of 8 m.

10.1.1.5 To ensure the worst case is assessed the value presented in the ES will be taken forward. To confirm the footprint of cable rock protection at the Greenlink interconnector cable crossing is based on 150m length and 14 m width, resulting in a worst case 150 x 14 m = **2,100 m²** (**0.0021 km²**).

Long Term Habitat Loss at Turbot Bank

10.1.1.6 Following confirmation of the maximum footprint of the rock protection for the Greenlink cable crossing rock protection at Turbot Bank of 2,100 m² (0.0021 km²) (see above), a summary of the predicted spatial extent of the long-term habitat loss of the Annex I sandbank Turbot Bank is presented herein.

10.1.1.7 The 0.0021 km² rock protection at the Greenlink crossing, represents 0.011% of the total area occupied by Turbot Bank within the SAC boundary (19.1 km²). The total area of Turbot Bank (e.g. the total area both inside the SAC and outside of it) is 24.05 km², and therefore, this represents 0.0087% of the entire bank. The proposed 0.0021 km² area of rock protection corresponds with 0.0041% of the 51.59 km² total Annex I Sandbank habitat reported to be present within the boundary of the Pembrokeshire Marine SAC. Although this value is in excess of the 0.0001% stated in the RIAA, the increase is not considered sufficient to change the conclusion of that assessment.

10.1.1.8 With respect to the conservation objectives for the SAC, there is no indication that permanent/long term habitat loss will lead to a reduction in environmental quality, nor will it inhibit natural environmental processes. It is predicted that there will be a slight loss of habitat extent; however, given that the extent and distribution is currently deemed to be in favourable condition, the magnitude of the impact on the Annex I habitat qualifying features of the site is considered to be negligible and would result in an insignificant change in the baseline condition.

10.1.1.9 Based on these assessments, it is determined that there is **no potential for an adverse effect on integrity, having regard to the conservation objectives of sandbank features of the Pembrokeshire Marine SAC from any pressures associated with temporary/permanent habitat loss/disturbance.**

10.1.2 Impact on Form and Function of Turbot Bank

10.1.2.1 NRW Advisory stated that *"the potential impacts from cable protection on the form and function of the Annex I Sandbank feature have not been fully assessed".* However, it is considered that the original assessment was based on the best available evidence, and that the conclusions presented were correct and appropriate.

10.1.2.2 The assessment of potential changes to the morphology of Turbot Bank in the Project ES utilises modelled patterns of sediment transport, which describe a spatially complex pattern near and around Turbot Bank. The conclusions of the assessment are based, partially, on the lack of direct linkage (in terms of sediment transport pathways) between Turbot Bank and areas of seabed where external cable protection rock berms might be present (refer to Section 2.6). The assessment also notes that the cable protection rock berms have little to no potential to block, or otherwise change, the magnitude or direction of long-term sediment transport, locally or regionally elsewhere, indirectly through changes to patterns of currents or waves.

10.1.2.3 The results of this assessment, and the scope for additional assessment was discussed with NRW Advisory in a subsequent Expert Topic Group (ETG) meeting (25 May 2022). During this meeting, it was agreed that the existing assessment provided a reasonable theoretical conclusion, on the basis of the available evidence. Remaining uncertainty in the details of the final impact description relate to the baseline understanding of sandwave migration rates on Turbot Bank (ideally requiring additional historical survey data, which do not exist to our knowledge) and the finer detail of sediment transport pathways and linkages in the wider area (presently supported by regional tidally driven sediment transport modelling). It was also agreed that there are no other additional data sources, and no obvious other assessment approaches that could provide a more robust assessment than that already provided.

10.1.2.4 The basis and conclusions of the original assessment have been reviewed, accounting for the comments raised regarding uncertainty detailed above. The Project stands by the findings and conclusions of the existing assessment. We trust it is understood and agreed that no fundamentally new evidence or assessment can be offered at this time. However, as set out within the Project ES and the Outline Environmental Monitoring Plan (OEMP), (prepared post ES submission and included as part of this submission of supplementary information), the Applicant (BGW) is committed to undertaking pre- and post-installation bathymetric surveys of the ECC, with a particular focus on areas of specific interest. Such areas include the section of the ECC that passes close to Turbot Bank, therefore, future monitoring of this area will provide further data to inform this issue and validate the predictions of this assessment.

10.1.3 Extent of Annex I Features in the Pembrokeshire Marine/Sir Benfro Forol Special Area of Conservation

Data Sources

10.1.3.1 The Applicant acknowledges that there was a discrepancy between the spatial extent of Annex I features of the Pembrokeshire Marine/Sir Benfro Forol Special Area of Conservation (SAC) presented in the Environmental Statement (ES), and the Habitats Regulations Assessment RIAA.

10.1.3.2 Within the ES Volume 1 Chapter 9: Marine and Coastal Ecology (hereafter referred to as Chapter 9), all values cited for the extent of Annex I features within the Pembrokeshire Marine SAC were sourced from the Lle Geo-Portal (Lle Geo-Portal, 2022). The shapefiles exported from the Lle Geo-Portal, had been used in all relevant maps in the chapter and this data source had been referenced throughout the chapter.

10.1.3.3 Within the RIAA, all values cited for the extent of Annex I features were sourced from the Standard Data Form (JNCC, 2015a). The Standard Data Form was first compiled in October 1997, and this was the latest update, dated December 2015.

10.1.3.4 Within the ES, Chapter 9 (Section 9.6.5 Annex I Interaction Summary; paragraphs 9.6.5.1-9.6.5.2) there is reference to the two different data sources used to inform the assessments in the ES, and the RIAA.

10.1.3.5 MarineSpace sought clarification from Natural Resources Wales (NRW Advisory), by email on the 08 June 2022, as to whether calculations in the assessments are to be based on the Lle Geo-Portal (as used in the ES), or the JNCC Standard Data Form (as used in the RIAA). NRW Advisory responded by email on the 14 June 2022, confirming that the figures from the Lle Geo Portal are to be used (as presented in the ES), as these are the most up to date.

10.1.3.6 The confirmed spatial extents for the relevant Annex I features are listed in Paragraphs 10.1.3.7 - 10.1.3.9 below, and as cited in the ES, have been sourced from the Lle Geo-Portal.

Extent of Annex I Reef

10.1.3.7 The spatial extent of Annex I reef (geogenic) within the Pembrokeshire Marine SAC is **444.68 km^2**. This is represented by **433.15 km^2** subtidal reef and **11.53 km^2** intertidal reef.

Extent of Annex I Subtidal Sandbank

10.1.3.8 The spatial extent of Annex I subtidal sandbanks which are slightly covered by seawater all the time (hereafter referred to sandbanks), within the Pembrokeshire Marine SAC is **51.59 km^2**.

Extent of Annex I Intertidal Mudflats and Sandflats

10.1.3.9 The spatial extent of Annex I intertidal mudflats and sandflats within the Pembrokeshire Marine SAC is **19.01 km^2**.

10.1.3.10 The clarification of spatial extents for Annex I habitats as descried above (Paragraphs 10.1.3.7 - 10.1.3.9) does not affect the determinations presented within the RIAA and, as such, no amendments are required to the conclusions presented for the HRA.

10.2 Marine Mammals

10.2.1 Incorporating Dose Response Values into Calculations of Disturbance

10.2.1.1 The use of dose response curves in calculations of disturbance ensures that assessment accounts for the proportional decrease in occurrence of harbour porpoise with decreasing range from the piling site, as measured using CPODs.

10.2.1.2 This approach recognises that disturbance is not binary, and there is not a hard threshold between areas where disturbance is expected and areas where it is not. This allows differentiation between areas close to the noise source, where likelihood of disturbance is high, and areas further away, where it is lower.

10.2.1.3 The dose response approach was incorporated into assessment of spatial extent of disturbance within the SAC, by reducing the area occupied by each 5 dB noise contour class, based on the dose response value. As such, an area of 50 km^2 within an SAC, with a dose response value of 0.5, would result in an area of SAC impacted of 25 km^2.

10.2.1.4 The relevant Conservation Objective of the West Wales Marine SAC is that *"There is no significant disturbance of the species"*. Disturbance is considered significant if it leads to the exclusion of harbour porpoise from a significant portion of the site. Noise disturbance within an SAC from a plan/Project individually or in combination is significant if it excludes harbour porpoises from more than:

- 20% of the relevant area of the site in any given day; or
- An average of 10% of the relevant area of the site over a season.

10.2.1.5 However, there is no agreed threshold available for what level of disturbance results in exclusion of porpoise (other than the JNCC *et al.* (2020) 26 km EDR). The displacement of porpoise varies with the dose of the noise received; this is the principle underlying the use the dose-response curve.

10.2.1.6 While there is the potential for disturbance impacts to occur down to 120 dB SELs according to the dose-response curve, it is important to note that very few porpoise are predicted to respond at this level (1.2% of porpoise respond). The Applicant does not consider this level of response to be a significant disturbance, and as such does not consider it to be a suitable threshold against which to assess the Conservation Objectives of the SAC.

10.2.1.7 Graham *et al.* (2019) reports that there is 50% probability of response from an individual within 7.4 km of the noise source (95% CI: 5.7–9.4). The West Wales Marine SAC is 11.3 km from the array area at its closest point. As such, should this 50% probability of response be used for the threshold for disturbance, then the area of disturbance within the SAC would be 0 km^2. Although none of the methods discussed offer a perfect determination of disturbance, the application of dose-response values provides an effective means of accounting for decrease in response with increased distance from the noise source.

10.2.1.8 In view of these factors, the approach to assessment as presented in the RIAA is considered appropriate and sufficient to support the conclusion that there would be *"no significant disturbance of the species".*

10.2.2 Sites Screened into Assessment

10.2.2.1 In their consultation response NRW Advisory notes:

“The list of sites screened in appears incomplete. In relation to the iterative approach recommended by NRW, all sites included in “Volume 3. Technical Appendix 8.2: Habitats Regulations Assessment Screening Report Table 10.2: Sites screened in for the next stage of the assessment for the Erebus Project and relevant onshore avian qualifying features” should also be included here and in the AA. If no adverse effect is concluded for a nearby site, then an AEOSI can be ruled out on the more distant sites, but this conclusion still reflects to them being included in the AA. Sites beyond the first sites with a no AEOSI conclusion are not retroactively screened out of the AA.”

10.2.2.2 It is unclear which list of sites is being referred to in this comment. In line with NRW (2020a) guidance, all sites within the appropriate MMMU were screened into assessment (Figure 10-1). However, an iterative approach was then adopted, where assessment is carried out for the closest site to the Project footprint. If an Adverse Effect On Site Integrity (AEOSI) was determined, then assessment was carried out for the next closest site. If no AEOSI was determined, more distant sites were not considered further.

10.2.2.3 A full list of sites was not included within ES Volume 3 Technical Appendix 8.2 HRA Screening Report, in an effort to manage chapter length. However, it is noted that the following text may have inaccurately suggested that it listed all sites screened into assessment:

"This assessment is provided to determine whether Project activities can reasonably be expected to result in an adverse effect on the integrity of the following sites, based on consideration of the respective conservation objectives:

- *West Wales Marine/Gorllewin Cymru Forol SAC (harbour porpoise);*
- *Pembrokeshire Marine/Sir Benfro Forol SAC (grey seal);*
- *Cardigan Bay/Cae Ceredigion SAC (bottlenose dolphin);*
- *Pen Llŷn a’r Sarnau/Lleyn Peninsula and the Sarnau SAC (bottlenose dolphin)."*

10.2.2.4 In view of this. It is suggested that the text should be modified to read as follows:

10.2.2.5 This assessment is provided to determine whether Project activities can reasonably be expected to result in an adverse effect on the integrity of the sites listed in Table 10-1 and Table 10-2, based on consideration of the respective conservation objectives. In line with NRW (2020a) guidance, all sites within the appropriate MMMU were screened into assessment. However, an iterative approach was then adopted, where assessment is carried out for the closest site to the Project footprint. If an Adverse Effect On Site Integrity (AEOSI) was determined, then assessment was carried out for the next closest site. If no AEOSI was determined, more distant sites were not considered further. It should be noted that due to the high connectivity between the Cardigan Bay/Bae Ceredigion SAC and the Pen Llŷn a’r Sarnau/Lleyn Peninsula and the Sarnau SAC, both of these sites have been subject to detailed assessment. Following adherence to this approach, detailed assessment has focussed on the following sites:

- West Wales Marine/Gorllewin Cymru Forol SAC (harbour porpoise);
- Pembrokeshire Marine/Sir Benfro Forol SAC (grey seal);
- Cardigan Bay/Bae Ceredigion SAC (bottlenose dolphin); and

- Pen Llŷn a'r Sarnau/Lleyn Peninsula and the Sarnau SAC (bottlenose dolphin).

Table 10-1: Screening results in relation to Annex II pinniped species for Project Erebus

Site Code	Country	Site Name	Category of Interest Feature	Distance to Array (km)	Distance to ECC (km)	Inside 12 nm limit (Yes/No)
UK0013116	Wales	Pembrokeshire Marine/Sir Benfro Forol SAC	Grey seal	16.5	0	Y
UK0013114	England	Lundy SAC	Grey seal	63.7	54.7	Y
UK0012712	Wales	Cardigan Bay/Bae Ceredigion SAC	Grey seal	85.8	49.1	Y
IE0000707	Ireland	Saltee Islands SAC	Grey seal	87	92.8	N
UK0013117	Wales	Pen Llŷn a`r Sarnau/Lleyn Peninsula and the Sarnau SAC	Grey seal	137.5	99.9	Y
UK0013694	England	Isles of Scilly Complex	Grey seal	163.7	169.2	Y

Table 10-2: Sites screened in and screened out of the next stage of assessment for Project Erebus in relation to Annex II Cetacean species

Site Code	Country	Site Name	Category of Interest Feature	Distance to array (km)	Distance to ECC (km)	Inside 12 nm limit (Yes/No)
UK0030397	Wales	West Wales Marine/Gorllewin Cymru Forol SAC	Harbour porpoise	11.3	0	Y
UK0030396	Wales	Bristol Channel Approaches /Dynesfeydd Môr Hafren SAC	Harbour porpoise	26.6	20.8	Y
UK0012712	Wales	Cardigan Bay/Bae Ceredigion SAC	Bottlenose dolphin	85.8	49.1	Y
IE0000707	Ireland	Saltee Islands SAC	Bottlenose dolphin	87	92.8	Y
IE0000781	Ireland	Slaney River Valley SAC	Bottlenose dolphin	103.3	108.5	Y
UK0013117	Wales	Pen Llŷn a`r Sarnau/Lleyn Peninsula and the Sarnau SAC	Bottlenose dolphin	137.5	99.9	Y
IE0003000	Ireland	Rockabill to Dalkey Island SAC	Bottlenose dolphin; Harbour porpoise	196.4	182.2	Y
UK0030398	Wales	North Anglesey Marine /Gogledd Môn Forol SAC	Harbour porpoise	199.7	170.8	Y

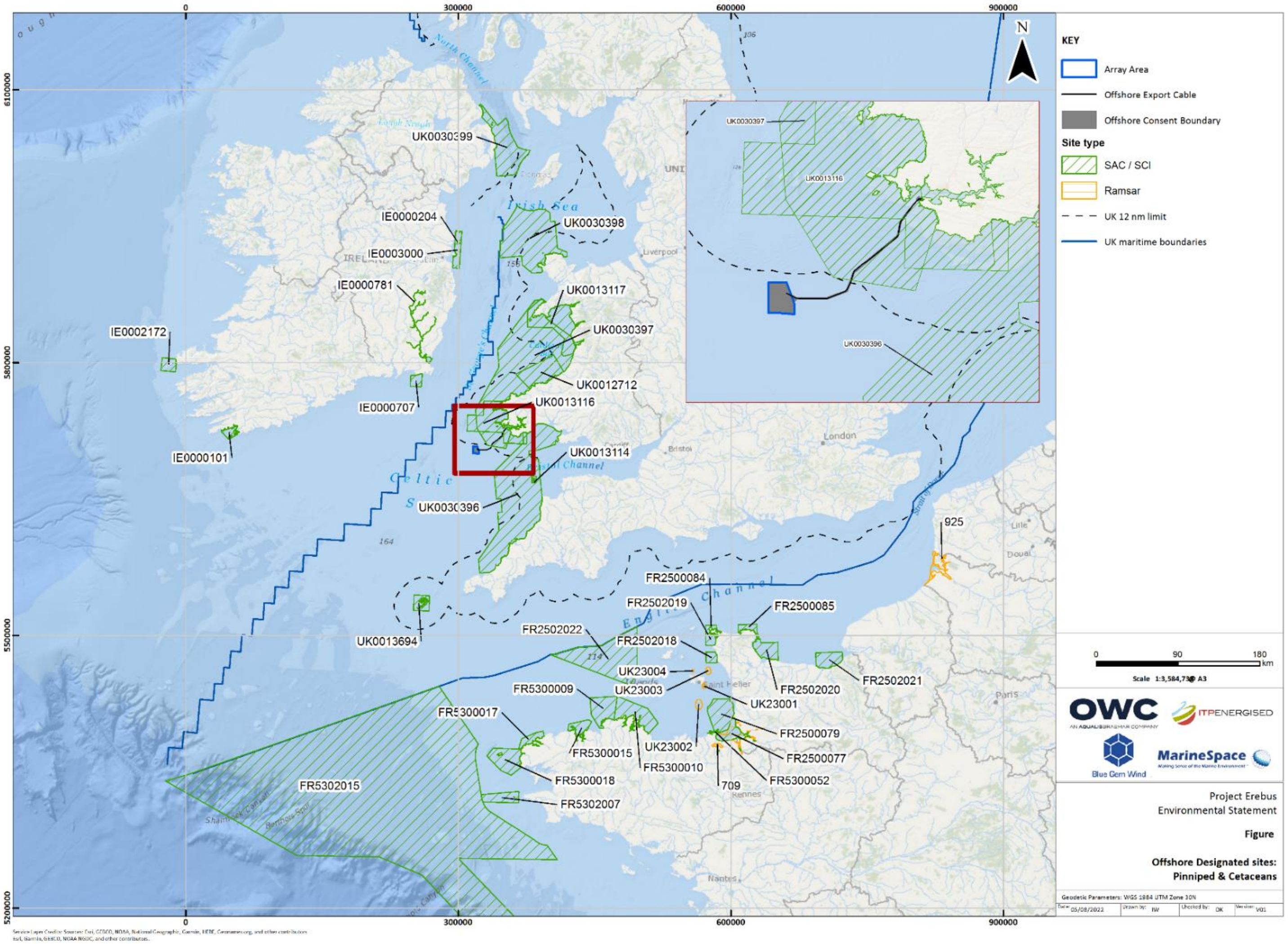
Site Code	Country	Site Name	Category of Interest Feature	Distance to array (km)	Distance to ECC (km)	Inside 12 nm limit (Yes/No)
IE0000204	Ireland	Lambay Island SAC	Bottlenose dolphin	222.3	207.4	Y
FR2502022	France	Nord Bretagne DH SCI/SAC	Bottlenose dolphin; Harbour porpoise	234.7	235.8	N
IE0000101	Ireland	Roaringwater Bay and Islands SAC	Harbour porpoise	257.3	264.4	Y
FR5302015	France	Mers Celtiques - Talus du golfe de Gascogne SCI/SAC	Bottlenose dolphin; Harbour porpoise	258.9	263.4	N
FR5300009	France	Côte de Granit rose-Sept-Iles SCI/SAC	Bottlenose dolphin; Harbour porpoise	295.2	295.4	Y
UK0030399	Northern Ireland	North Channel	Harbour porpoise	297.9	276.1	N
FR5300010	France	Tregor Goëlo	Bottlenose dolphin Harbour porpoise	307.3	306.2	Y
FR2500084	France	Récifs et landes de la Hague	Bottlenose dolphin	312.8	306.2	Y

Site Code	**Country**	**Site Name**	**Category of Interest Feature**	**Distance to array (km)**	**Distance to ECC (km)**	**Inside 12 nm limit (Yes/No)**
FR5300017	France	Abers - Côte des légendes	Bottlenose dolphin; Harbour porpoise	313.2	315.4	Y
FR5300015	France	Baie de Morlaix SCI/SAC	Harbour porpoise	313.6	314.9	Y
FR2502019	France	Anse de Vauville SCI/SAC	Bottlenose dolphin	318.6	312.3	Y
FR5300018	France	Ouessant-Molène SCI/SAC	Bottlenose dolphin Harbour porpoise	324.4	328.1	Y
FR2502018	France	Banc et récifs de Surtainville SCI/SAC	Bottlenose dolphin	331.9	326.1	Y
UK23004	Jersey, Channel Islands	Les Pierres de Lecq (the Paternosters) Jersey Ramsar Site	Bottlenose dolphin	334.5	329.7	Y
IE0002172	Ireland	Blasket Islands SAC	Harbour porpoise	341.7	348.5	Y
FR2500085	France	Récifs et marais arrière-littoraux du Cap Lévi à la Pointe de Saire SCI/SAC	Bottlenose dolphin	341.9	334.5	Y

Site Code	Country	Site Name	Category of Interest Feature	Distance to array (km)	Distance to ECC (km)	Inside 12 nm limit (Yes/No)
UK23003	Jersey, Channel Islands	Les Écréhous & Les Dirouilles, Jersey Ramsar Site	Bottlenose dolphin	348.7	343.5	Y
UK23001	Jersey, Channel Islands	South East Coast of Jersey, Channel Islands Ramsar Site	Bottlenose dolphin	357.5	352.7	Y
UK23002	Jersey, Channel Islands	Les Minquiers, Jersey Ramsar Site	Bottlenose dolphin	363.4	359.4	Y
FR2502020	France	Baie de Seine occidentale SCI/SAC	Bottlenose dolphin	366.2	353.6	Y
FR5302007	France	Chaussée de Sein SCI/SAC	Bottlenose dolphin; Harbour porpoise	374.3	377.4	Y
FR2500079	France	Chausey SCI/SAC	Bottlenose dolphin	376.5	368.8	Y
FR5300052	France	Côte de Cancale à Paramé SCI/SAC	Bottlenose dolphin	396.8	394.5	Y
FR2500077	France	Baie du Mont Saint-Michel SCI/SAC	Bottlenose dolphin	400.4	396.5	Y

Site Code	Country	Site Name	Category of Interest Feature	Distance to array (km)	Distance to ECC (km)	Inside 12 nm limit (Yes/No)
709	France	Baie du Mont Saint-Michel Ramsar Site	Bottlenose dolphin	403.4	398.8	Y
FR2502021	France	Baie de Seine orientale SCI/SAC	Bottlenose dolphin	430.6	422.6	Y
925	France	Baie de Somme Ramsar Site	Bottlenose dolphin	511.5	500	Y

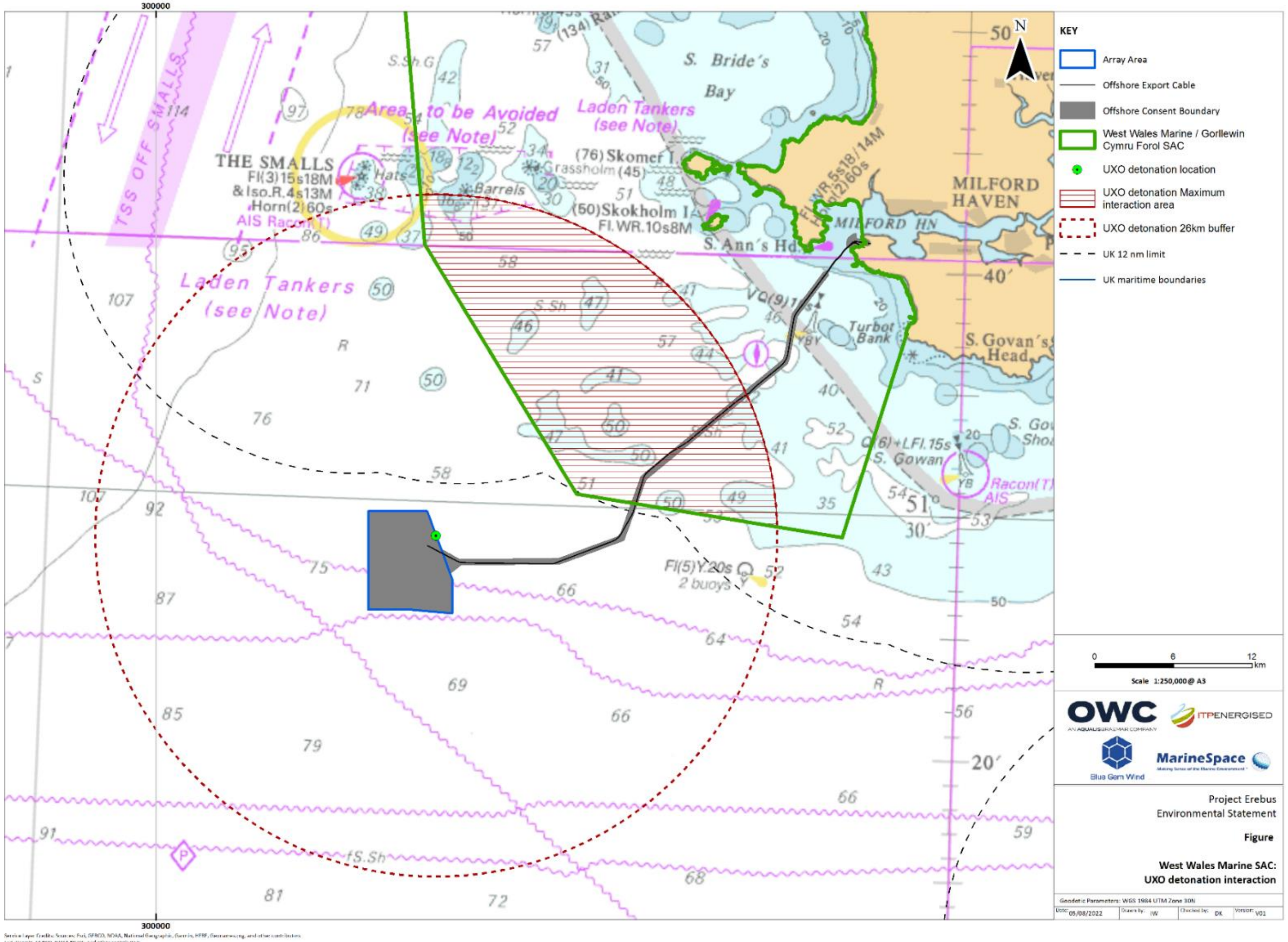
Figure 10-1: Map showing the Project site, and all of the nature conservation sites screened into assessment for Annex II marine mammal receptors.



10.2.3 High Order UXO Clearance

10.2.3.1 Figure 10-2 illustrates the maximum overlap between the 26 km impact range and the West Wales Marine SAC, from a point within the Project array area. This information is provided in response to JNCC's comment on row 193 of the ORML2170 Technical and General Consultation Responses spreadsheet.

Figure 10-2: Spatial overlap between a 26 km impact range from a high order UXO clearance event and the West Wales Marine SAC. The location of this example UXO location was chosen to provide the worst case maximum overlap between the effect range and the SAC site.



10.2.4 Consequences of PTA-onset

10.2.4.1 NRW Advisory highlighted that the RIAA did not detail what consequences might result from PTS onset, and warned that *"Without evidence to justify an alternative approach a precautionary approach would be to consider the PTS-onset to be sufficient to substantially reduce survivability to such a point where it would be considered fatal".*

10.2.4.2 With respect to PTS-onset from a single pulse of noise, National Oceanic and Atmospheric Administration (NOAA) has set the onset of TTS at the lowest level that exceeds natural recorded variation in hearing sensitivity (6 dB), and assumes that PTS occurs from exposures resulting in 40 dB or more of TTS measured approximately four minutes after exposure (NMFS, 2018).

10.2.4.3 PTS-onset means a reduction in hearing sensitivity in a specific frequency range, and not that the animals are deafened.

10.2.4.4 In terms of potential for PTS-onset to affect vital rates, Booth *et al.* (2018) state:

> *"In considering how any PTS could affect vital rates (i.e. probability of survival, probability of fertility), experts discussed the mechanisms by which this could occur. In general, experts noted that where communication has a significant social or reproductive function, that this might be a means by which survival and/or reproduction are affected. Experts noted however that PTS would likely occur over a small frequency range and that much of the energy of communication signals either fell outside the likely range affected by PTS (see section 3.2.2) or that the loss of part of the signal would likely not affect detection of the communication signals."*

10.2.4.5 It is also noted that:

> *"there was a large natural variability in hearing sensitivity across animals sampled (e.g. see Castellote et al. 2014); therefore, it was important to realise that reduced hearing ability does not necessarily mean a less fit animal (i.e. an animal of lower fitness)."*

10.2.4.6 With respect to high-order UXO detonation, most of the acoustic energy produced is below a few hundred Hz, decreasing on average by about SEL 10 dB per decade above 100 Hz, and there is a pronounced drop-off in energy levels above ~5-10 kHz (von Benda-Beckmann *et al*., 2015; Salomons *et al*., 2021). Therefore, the primary acoustic energy from a high-order UXO detonation is below the region of greatest sensitivity for most marine mammal species considered here (Southall *et al*., 2019). If PTS were to occur within this low frequency range, it would be unlikely to result in any significant impact to vital rates.

10.2.5 PTS-onset from Other Construction Activities

10.2.5.1 Within its consultation response NRW Advisory highlighted that the assessment of PTS-onset from other construction activities within the RIAA was overly precautionary, and the resultant conclusion that these activities would result in PTS-onset in *"up to 70 individuals"* would be likely to result in AEOSI. This assessment was based on the unlikely scenario that an animal would remain within close proximity of the noise source for a 24-hour period. In recognition of this, an alternative assessment is presented below, which accounts for the likelihood that any marine mammal within the injury zone would move away from the vicinity of the vessel and the construction activity.

10.2.5.2 Using the non-impulsive weighted SEL_{cum} PTS-onset thresholds for stationary receptors from Southall *et al*. (2019) resulted in estimated PTS impact ranges that were variable between non piling construction activities (Table 10-3). PTS impact ranges were from <10 m to 820 m for VHF cetaceans (i.e. harbour porpoise). These noise sources will have a local spatial extent, short term duration and are intermittent; meaning that, with the most precautionary estimates, a marine mammal would have to remain within close proximity (<820 m) for a 24-hour period for PTS onset to occur. This is an extremely unlikely scenario, as it is far more likely that any marine mammal within the injury zone would move away from the vicinity of the vessel and the construction activity.

10.2.5.3 Therefore, PTS impact ranges for fleeing receptors have also been presented (Table 10-3). This resulted in PTS impact ranges of <10 m for all marine mammal groups for all non piling construction activity; a marine mammal receptor would have to be within 10 m of the continuous noise source at the start of the activity to acquire the necessary exposure to induce PTS. Given that available evidence suggests harbour porpoise are likely to be temporarily displaced by vessel activity (e.g. Benhemma-Le Gall *et al.*, 2021), it is considered highly unlikely that any individuals will be present within the PTS impact ranges predicted.

Table 10-3: Summary of the source level (SEL_{cum} dB re 1 μPa @ 1 m RMS) and PTS-onset impact ranges (m) in harbour porpoise for the different construction noise sources using the non-impulsive criteria from Southall *et al.* (2019)

Noise source	Source Level	Stationary Receptor	Fleeing Receptor
Vessel movement (large)	168	<10	<10
Vessel movement (medium)	161	<10	<10
Backhoe dredging	165	<10	<10
Suction dredging	186	400	<10
Cable laying	171	40	<10
Trenching	172	40	<10
Rock placement	172	530	<10
Drag embedment anchors	171	70	<10
Suction pile installation	192	820	<10

Noise source	Source Level	Stationary Receptor	Fleeing Receptor
Drilling	170.1	<10	<10

10.2.5.4 There is no indication that the potential for auditory injury caused by subsea acoustic emissions associated with Project construction activities would negatively impact conservation objectives for the West Wales Marine SAC site. The spatial area at risk within the zone of influence is very low, and it is not expected any animals will remain within the predicted impact range (<820 m) for the duration (24 hour period) where PTS onset would occur. As such, this is not expected to lead to a reduction in the viability of harbour porpoise populations designated at this site. There is also no evidence to suggest that this pressure would adversely impact any other factor required to maintain the favourable conservation status of the harbour porpoise feature. In view of these factors, it is determined that there is **no potential for an adverse effect on integrity, having regard to the conservation objectives of the harbour porpoise feature of the West Wales Marine SAC from any pressures associated with auditory injury from other construction activities.**

10.3 Ornithology

10.3.1 In-combination Assessment

10.3.1.1 The consultation response received from NRW Advisory flagged that the Project in-combination assessment did not include consideration of The TwinHub Floating Offshore Wind Demonstration Project. The ES submitted for this Project (Xodus, 2018) predicted that turbine structures may result in 40 northern gannet collisions as a worst-case scenario. However, none of the mortalities predicted to occur as a result of the TwinHub project were apportioned to the Grasshom SPA population of northern gannet.

10.3.1.2 Therefore, the in-combination assessment originally conducted for the Grassholm SPA in the RIAA does not require inclusion of the TwinHub project. For impacts to regional populations, refer to Section 0.

10.3.1.3 As such, with respect to the conservation objectives of the Grassholm SPA, there is no indication that the potential levels of mortalities from collision events associated with Project and other in combination developments would be significant in terms of the classified population of northern gannet at this site. The size of the population is expected to remain stable, and the distribution of the population maintained. Despite the small increase in mortality relative to background levels, the northern gannet population will remain sustainable within the Grassholm SPA in the long term. There is no evidence to suggest that displacement effects will reduce numbers within this population relative to the North Atlantic population as whole. Therefore, it is assessed that **no potential for an in combination adverse effect on integrity, having regard to the conservation objectives of northern gannet features of the Grassholm SPA from any pressure associated with collision event**

Chapter 11 Water Framework Directive Compliance Assessment

11.1 Potential Effects on Maerl beds

11.1.1.1 The consultation response provided by NRW Advisory included various comments highlighting that, although Project activities do not directly overlap with Maerl beds, there is good reason to believe that secondary effect pathways, such as plumes caused by sediment disturbance during cable installation near to landfall, or HDD drilling activities may interact with these features.

11.1.1.2 The Applicant accepts this point, and acknowledges that the potential Project secondary effects pathways may extend to within 500 m of the Maerl beds, and therefore this receptor should be scoped in to WFD compliance assessment. Further assessment on risk of impact from this pathway is provided below.

11.1.2 Plumes Associated with Cable Burial Activities Close to Landfall

11.1.2.1 Section 2 of this report provides additional numerical modelling to assess the magnitude, duration and extent of local increases in Suspended Sediment Concentration (SSC) within or close enough to Milford Haven that there may be a potential impact on the Maerl beds that are present. This assessment presents the following conclusions:

- Under spring tidal conditions, fine sediment suspended by trenching in West Angle Bay and the approaches to Milford Haven can cause a weak sediment plume to extend into the estuary, and overlap with the known location of Maerl beds;
  - The maximum modelled increase in SSC within the area of live Maerl beds is approximately 30 mg/l, however this peak effect was only briefly observed (order of 10 minutes), in 1 of the 4 release timing scenarios (starting in West Angle Bay at HW+3, approximately peak ebb tide);
  - Modelled increases in SSC within the area of live Maerl beds are more typically limited to 10 to 20 mg/l, lasting for approximately 1 to 4 hours, for 2 of the 4 release timing scenarios (starting in West Angle Bay at HW, approximately high water slack, and at HW+3, approximately peak ebb tide). This occurs because plumes arising in and close to West Angle Bay during the initial part of these model periods are somewhat contained and restrained by the naturally low local current speeds. By the time the sediment plume reaches the main channel flow (several hours later), the remainder of the ebb tide encourages dispersion across the estuary width. The following flood tide then transports the plume into the estuary far enough to overlap the Maerl beds;

  - Modelled increases in SSC within the area of live Maerl beds are negligible or zero at any time for 2 of the 4 release timing scenarios (starting in West Angle Bay at HW-6, approximately low water slack, and at HW-3, approximately peak flood tide). This occurs because plumes arising in and close to West Angle Bay during the initial part of these model periods are somewhat contained and restrained by the naturally low local current speeds. By the time the sediment plume reaches the main channel flow (several hours later), the flood tide is nearly complete so does not then transport the plume far enough into the estuary to overlap the Maerl beds. Ongoing trenching work progressively moves further south during the following HW slack and ebb period, and further releases during the next flood tide are too distant to affect the Maerl beds;

- Under neap tidal conditions, modelled increases in SSC within the area of live Maerl beds are negligible or zero at any time for all of the 4 release timing scenarios;
  - The tidal current excursion distance is sufficient to advect the sediment plume to the near vicinity of the Maerl beds, however, the different patterns of current speed and direction confine the plume to the main channel to the south;
  - Similar release timing effects, to those described above for spring tidal conditions, are also noted;
- Sediment deposition thickness in and around the area of the live and/or dead Maerl beds is predicted to be <<1 mm (<1 g/m²) in all cases, which is not measurable in practice and will be, at most, comparable to normally occurring patterns as a result of natural processes and other vessel movement related disturbances.

11.1.3 Drilling Fluid Release During HDD at Landfall

11.1.3.1 Additional modelling has also been carried out to determine the likely plume effects associated with drilling fluids/muds (mainly bentonite clay in water). These outcomes are also reported in Section Chapter 2.

11.1.3.2 Plume modelling results for drilling fluid release during HDD at landfall were analogous to those for cable burial activities close to landfall with the following differences:

- Modelled increases in SSC within the area of live Maerl beds are more typically limited to less than 10 mg/l, lasting for approximately 1 to 4 hours, for 5 of the 12 release timing scenarios (as opposed to 10-20 for cable burial activities close to landfall);
- Sediment deposition thickness in and around the area of the live and/or dead Maerl beds is predicted to be <1 mm (<20 g/m²) in all cases, which is not measurable in practice and will be, at most, comparable to normally occurring patterns as a result of natural processes and other vessel movement related disturbances (as opposed to <<1 mm (<1 g/m²) for cable burial activities close to landfall).

Assessment of Potential Impacts from Predicted Plume Effects on Maerl Receptors

11.1.3.3 MarLIN MarESA sensitivity assessments report that Maerl beds have Medium sensitivity to changes in SSC (Medium resistance, Very Low resilience), and High sensitivity to light smothering and changes in siltation rate (No resistance and Very Low resilience).

11.1.3.4 With respect to changes in SSC, the Medium sensitivity of Maerl beds relates to availability of light required for photosynthesis. Maerl beds are limited to shallow waters and this depth distribution is led by the photosynthetic requirements of the thin layer of coralline algae that grow upon the underlying sediment formed 3d structures (Birkett *et al.,* 1998). However, as an increase in turbidity would reduce photosynthesis, but is unlikely to result in mortality, the Maerl would regain photosynthetic vigour immediately after the elevated levels of SSC fall to normal levels (Marine Scotland, 2022). Given that where modelled increases in SSC reach the area of live Maerl beds, this increase was limited to 1 to 4 hours, it is unlikely that this change would be sufficient to affect the living Maerl. The Maerl beds would regain photosynthetic vigour immediately after the elevated levels of SSC fall to normal levels. In addition, under the requirements of the WFD, activities are compliant if they do not result in a non-temporary effect. The changes described above would last less than a single tidal cycle and therefore cannot be considered to be non-temporary.

11.1.3.5 Maerl beds have high sensitivity to light smothering. It has been reported that release of organic waste from fish both reduces live Maerl cover and causes a decrease in infaunal biodiversity associated with this habitat (SNH, 2006). Important, functional or characterising species such as *Ophiothrix fragilis*, *Psammechinus miliaris* and *Hyas araneus* are highly intolerant of smothering and these events would result in a major decline in species richness. Once a population has become extinct, the lack or propagules means that it is unlikely that it will be re-established. Even if reproductive propagules arrive from elsewhere, the low growth rate of Maerl means that it will take a very long time for the habitat to re-establish to its original condition. However, the level of sediment deposition predicted to occur at Maerl beds in Milford Haven is very low; (<<1 mm (<1 g/m^2) in all cases for cable burial activities close to landfall and <1 mm (<20 g/m^2) in all cases for HDD at landfall). This degree of sediment deposition is not measurable in practice and will be, at most, comparable to normally occurring patterns as a result of natural processes and other vessel movement related disturbances. This should be contextualised against the benchmarks used in assessment of feature sensitivity. The assessments presented by MarLIN are based on the pressure definitions developed by the OSPAR Intersessional Correspondence Group on Cumulative Effects (ICG-C). The benchmark for light smothering is up to 5 cm depth. The predicted level of sediment deposition at the Milford Haven Maerl beds is negligible relative to this benchmark. As such - and considering that background variations in sediment deposition would be expected to occur naturally due to natural processes and sediments disturbed by vessel movement - this change is not expected to result in any adverse effects on these Maerl beds.

11.1.3.6 In view of the evidence presented above, the proposed activities will not result in significant effects to Maerl beds within Milford Haven and, therefore, they are not expected to jeopardise the attainment of WFD objectives for the Milford Haven Outer waterbody.

11.2 Invasive Non-native Species

11.2.1 Mitigation

11.2.1.1 The scoping stage for the Project Water Framework Directive (WFD) compliance assessment determined that there was potential for Project activities to result in introduction or spread of Invasive Non-Native Species (INNS), which could jeopardise the Good WFD status of affected WFD waterbodies, or prevent those which are not already at Good status, from achieving their objectives under the WFD.

11.2.1.2 ES Volume 3 Technical Appendix 9.4: Offshore INNS Plan, provides a detailed assessment of the risk that INNS may be introduced or spread, and outlined the mitigation measures that will be put in place to avoid this.

11.2.1.3 ES Volume 3 Technical Appendix 7.3: WFD Compliance Assessment of the Environmental Statement (ES), submitted in application for the Proposed Development, included assessment of risk posed by risk of INNS introduction and/or spread. However, in its consultation response, NRW Advisory requested additional details of mitigation measures that would be implemented to avoid adverse effects. Further detail on this pathway is provided below.

11.2.2 Pathways for Introduction

11.2.2.1 INNS can be introduced or spread to a site through a wide range of anthropogenic and natural pathways (Cook *et al.,* 2014); however, not all will be applicable at all sites (Cook *et al.,* 2015). The greatest risks are generally associated with slow moving vessels, or equipment that has arrived from another country or body of water, where INNS are known to be present.

11.2.2.2 Installation of hard substrate does not pose an introduction risk in itself, assuming clean/virgin material is used. However, there is risk of colonisation by INNS, increasing the rate of spread and/or acting as ‘stepping stones’ for INNS to extend their range to additional sites. It should be noted that the Proposed Development intends to use clean, virgin material and, thus, poses no risk of INNS introduction via this pathway.

11.2.2.3 The vessels and equipment associated with each phase of the Proposed Development were reviewed for their potential and risk to introduce, or spread, INNS to the site. The risk assessment has been based upon information and literature review, where applicable, and expert opinion and professional judgement, in order to conduct a site specific assessment. This judgement has been implemented in order to apply a ranking system (No Risk, Low Risk, Medium Risk, and High Risk) to site activities that may result in spread and/or introduction of INNS. See ES Volume 3, Technical Appendix 9.4: Offshore INNS Plan for full risk assessment of vessels and equipment associated with the Proposed Development introducing or spreading INNS.

11.2.3 Activities Identified as Potentially Introducing or Spreading INNS

11.2.3.1 Table 11-1 details activities identified as posing a risk of INNS introduction and/or spread.

Table 11-1: Activities associated with the Proposed Development identified as potentially introducing or spreading invasive non-native species

Project Phase	Activity
Construction	• Installation of anthropogenic structures (i.e., semi-submersible floating platforms and associated mooring system, and array and export cables and associated cable protection) in the Study Area; • Fabrication and towing of the semi-submersible floating platforms from outside the local area (i.e., outside Milford Haven); • Using vessels from outside the local area (i.e., outside Milford Haven).
Operation and maintenance	• Long-term presence of anthropogenic structures in the Study Area; • Maintenance of semi-submersible floating platforms, wind turbine generators, and associated ancillary equipment and cables; • Using O&M vessels from outside the local area (i.e., outside Milford Haven).
Decommissioning	• Removal of anthropogenic structures from the Study Area; • Cleaning of equipment and disposal of biofouling from equipment following decommissioning at the end of the Project lifespan; • Using vessels from outside the local area (i.e., outside Milford Haven).

11.2.4 Specific Mitigation Measures

11.2.4.1 In order to minimise the risk associated with INNS, the following mitigation measures will be adopted:

- Structures introduced to the Study Area should be from local or terrestrial (i.e. not marine) environments where possible, and should have appropriate anti-fouling treatment to minimise colonisation and spread of INNS, where applicable. If structures are brought in from other marine environments, or locations where INNS are known to be present but are not present within the Study Area, they should be checked and cleaned prior to being transported to the Study Area, to ensure that any INNS attached are removed and are not introduced to the site;
- All vessels utilised throughout any stage of the Project will adhere to the guidelines set out the International Maritime Organisation (IMO) Guidelines for the Control and Management of Ships' Biofouling to Minimise the Transfer of Invasive Aquatic Species (IMO, 2011); and International Convention for the Control and Management of Ship's Ballast Water and Sediments (IMO, 2017).

11.2.4.2 The guidelines include the use of a biofouling management plan and record book; installation and maintenance of the anti-fouling system; inspection, cleaning and maintenance of vessels; and guidance and standards associated with ballast water exchanges. Where possible, vessels will use Pembroke Port and the wider Milford Haven waterway, abiding by local biosecurity measures and requirements (MHPA, 2013). Any local (origin, on route, or destination) INNS or biosecurity measures will also be adhered to, where applicable, including port specific measures, and controls at any ports used throughout the duration of the Project.

11.2.4.3 Equipment and vessels should be cleaned in an appropriate manner, and any biofouling removed should be disposed of onshore. It is important that no material re-enters the marine environment, especially in locations outside the Study Area. Disposal of biofouling will be done in accordance with any local or port specific waste management procedures, such as those outlined in the Milford Haven Waste Management Plan (MHPA, 2013).

11.2.4.4 Project components should be inspected for the presence of attached INNS prior to removal. If INNS are identified, an agreed removal and re-check procedure should be followed (see also: cleaning of Project infrastructure and disposal of biofouling; ES Volume 3, Technical Appendix 9.4, Section 2.4.4). Where possible, Project components should be returned to local ports to minimise the risk of spreading INNS to areas outside the local area.

11.2.5 Contingency

11.2.5.1 Although it is expected that the mitigation measures detailed above will be sufficient to mitigate risks associated with INNS, the following steps are proposed in the event that INNS introduction/spread is identified:

- Suspected high alert species (GBNNSS, 2021a):
    - Obtain sample, or if not reasonable possible, obtain photographs of sample;
    - Compare organism with identification sheet/keys available online http://www.nonnativespecies.org/index.cfm?sectionid=47 (GBNNSS, 2021a);
    - Inform site users, and mark the area where INNS were recorded;
- High alert species confirmed (positive identification during Stage 1):
    - Enact containment measures, including isolation of area where INNS found and restrict vessel movements;
    - Conduct wider search of vessels and structures for further specimens;
    - Report INNS online http://www.nonnativespecies.org/index.cfm?pageid=549 or via email (GBNNSS, 2021b);
- Eradication or control (if further INNS specimens are found during Stage 2):
    - Contact GBNNSS for further advice;
    - Contact relevant regulators and authorities as appropriate (e.g. NRW, and Milford Haven Port Authority).

11.3 Migratory Fish

11.3.1.1 In its consultation response, NRW Advisory states that:

"NRW agree with the assessment by NPS, based on the Applicants' assessments that the Project will not prevent or adversely impacts attaining GES/GEP with regards to impacts to fish in the affected waterbodies. However, we note that in Appendix 7.1 WFD Assessment, section 1.7.4.1, paragraph 6, page 29, only migratory fish in Milford Haven Inner Waterbody are discussed as receptors, however migratory fish will have to pass through both the coastal and Milford Haven Outer waterbodies on the migration path, so these WBs should also be included."

11.3.1.2 The Applicant acknowledges that fish migrating to and from the Milford Haven Inner waterbody will also pass through the Milford Haven Outer and Pembrokeshire South waterbodies. An assessment of risk to migratory fish species passing through the Milford Haven Outer and Pembrokeshire South waterbodies is provided below.

11.3.2 Construction Phase

11.3.2.1 During the construction phase there is potential for impacts to migratory fish species passing through the Project primary or secondary zone of impact, through the following pathways:

- Temporary habitat disturbance/damage;
- Increased suspended sediment and sediment deposition;
- Low-level, non-impulsive subsea noise;
- High-level impulsive subsea noise (piling); and
- Disturbance, injury, and mortality from subsea noise produced via UXO.

11.3.2.2 It should be noted that within ES Volume 1, Chapter 10: Fish and Shellfish Ecology, impacts in excess of Minor Adverse were not predicted for any of these impact pathways.

11.3.2.3 With respect to temporary habitat disturbance, this pathway may occur due to cable installation, sandwave clearance, and installation of mooring lines/anchors/piling. This may lead to a loss of feeding resource for fish passing through the site during migration to/from breeding sites. However, the total area of seabed predicted to be subject to temporary disturbance, over the duration of the construction phase (1,354,504 m^2; 1.35 km^2), will not be disturbed at one time, as construction will be phased over 8 months. In addition, this area represents a small proportion of the total feeding areas available regionally and, therefore, it is likely that migratory fish species will have ample alternative feeding resource available. As stated, these effects will be short-term, and habitats will recover rapidly, following cessation of Project activities.

11.3.2.4 Increased suspended sediment concentrations and sediment deposition is likely to arise during the construction phase of the Project, via a wide range of activities, including installation of anchors/foundations, mooring line deployments, pre-cable installation works, export and array cable installation, cable protection installation, and landfall works including potential open-cut trenching, and floatation pit construction.

11.3.2.5 In areas with high proportions of fine sediment, and during periods of peak tidal flow, sediment plumes with increased SSC have the potential to extend up to 19 km downstream. However, the SSC of plumes dispersed over this distance are likely to be considered negligible, with SSCs reaching 50 mg/l at approximately 2 km, and settling through progressive dilution and dispersion over up to 3 days. Plumes in areas of fine and medium sand have the potential to extend up to 5 km and 2 km respectively, at SSCs of up to 150 mg/l, when released at the water's surface.

11.3.2.6 Plume extents from the surface release of coarser sediments, such as gravel and coarse sand, are determined to be limited to 100 m and 500 m respectively. When sediment disturbance occurs closer to the seabed, during activities such as post-installation cable burial, sediment dispersal is likely to be significantly reduced, however SSC at the point of release may be very high (hundreds of thousands). At a release height of 3 m from the seabed, dispersion distances are predicted to at 5 m, 30 m and up to 300 m for gravels, coarse sands, and fine sand respectively. In areas of exposed rock platform, or particularly large sediment size, no sediment plume would be expected as particle suspension cannot occur. In areas nearer to shore, background concentrations of SSC are likely to be higher, due to natural events including wave and surge effects, particularly during periods of stormy weather.

11.3.2.7 Mobile adult fish are considered unlikely to be impacted by changes in SSC, and the extents of resultant plumes will be temporary, and represent a small proportion of regional waters.

11.3.2.8 The impact of subsea acoustic emissions on fish has been assessed in detail within ES Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report.

11.3.2.9 Sea lamprey *Petromyzon marinus* and river lamprey *Lampetra fluviatilis* do not have swim bladders, and are therefore not considered sensitive to subsea acoustic effects. Although allis and twaite shad do possess swim bladders, modelling results indicated that for the majority of low-level, non-impulsive construction noise, fish with a swim bladder involved in hearing, would only experience recoverable injury (within 48 hours) if within 10 m of the source, with the exception of suction piling installation which indicated a distance of 20 m. Temporary Threshold Shift (TTS) (for 12 hours) would occur within a wider range of distances from between <10–60 m.

11.3.2.10 Should impact piling be required, a realistic worst-case scenario suggests TTS for fish with a swim bladder involved in hearing, to occur within a range of up to 9.9 km for fleeing fish. All other effects including recoverable injury, and mortality and potential mortal injury, would be limited to <100 m from the pile driving.

11.3.2.11 With respect to disturbance, injury, and mortality from subsea noise produced via UXO, mortality and potential injury to fish with a swim bladder involved in hearing, may occur at distances of up to 120 m following the deflagration of a UXO device using a 2 kg charge (the realistic worst case scenario). As this noise will be instantaneous, individuals will not be able to flee.

11.3.2.12 Given the small spatial scale of potential effects, and the high mobility of migratory fish, it is expected that this is associated with negligible risk of injury or barrier to migration.

11.3.3 Operation and Maintenance Phase

11.3.3.1 During the operation and maintenance phase there is potential for impacts to migratory fish species passing through the Project primary of secondary zone of impact through the following pathways:

- Long-term loss of feeding resource due to the presence of Project infrastructure;
- Temporary habitat disturbances from cable repair and remediation and catenary swept areas;
- Temporary disturbances to feeding habitat from sediment deposition via repair and remediation works;
- Fish aggregating device and collision effects; and
- Electromagnetic field effects from cables.

11.3.3.2 With respect to long-term loss of feeding resource, the worst-case scenario for long term habitat loss via installation of Project infrastructure is 163,001 m^2 (0.16 km^2). This represents a negligible proportion of total feeding resource regionally, and therefore it is likely migratory fish species will have ample alternative feeding resource available.

11.3.3.3 Planned and unplanned maintenance activities throughout the operation and maintenance phase of the Project may cause temporary habitat disturbance impacts through direct habitat abrasion, or through indirect effects related to sediment deposition. However, it is expected that the nature of the repairs will cause a similar disturbance as those outlined for temporary disturbances of habitats during the construction phase, but on a smaller spatial scale. As such, it is expected that this impact pathway presents a lower risk of impact than those assessed for the construction phase.

11.3.3.4 Unlike a number of tidal and wave devices, the semi-submersible floating platforms will display limited movement (influenced primarily through wind and tidal regimes) and should be considered as static structures with regard to subsea collisions. Collision risk is most likely during periods of high flow where fish may seek areas of reduced water velocity behind the platform, however due to its static nature, it is unlikely that any damage would result from a collision under these circumstances. Stationary infrastructure on the seabed is likely to be treated like natural seabed structure and is, therefore, unlikely to present any risk to individuals within the water column. Cables within the water column present a low surface area so collision is unlikely. Although there is a minor risk of entanglement, a worst-case scenario suggests a total of 35 lines across the array area, or a single cable per 1.24 km^2 of array area, resulting in the risk of entanglement being negligible.

11.3.3.5 Electromagnetic fields (EMF) can arise in the immediate vicinity of electrical cables. Within ES Volume 1, Chapter 10: Fish and Shellfish Ecology, it was determined that EMF influence will, therefore, be present across a total volume of 0.0039 km^3 across the Project, with this value including both the water column and seabed. EMF influence will be present within 0.0019 km^3 of seabed within the Proposed Development, and 0.0021 km^3 of the water column. This volume is considered negligible in the context of both the array and EEC. EMF effects will be confined to the highly localised area immediately surrounding the cable and, given that effects will often be shielded with rock protection, this is considered to pose low risk of impact to fish populations. In addition, migratory fish species are highly mobile, and capable of avoiding such highly localised areas, if these are outside their range of tolerance.

11.3.4 Decommissioning Phase

11.3.4.1 During the decommissioning phase there is potential for WTG, foundation and cable removal activities to impact migratory fish through the following pathways:

- Temporary feeding habitat disturbances via moorings and cable installation;
- Increased suspended sediment and sediment deposition; and
- Disturbance, injury and mortality from subsea noise produced via construction activities.

11.3.4.2 However, the magnitude of associated impacts is considered to be equal or lower that the equivalent pathways for the construction phase. As such, effects during decommissioning will not exceed those as assessed for the construction phase.

11.3.5 Summary

11.3.5.1 In conclusion, assessment of Project activities during construction, operation and maintenance, and decommissioning phases has shown that these activities do present impact pathways for migratory fish species passing through Milford Haven Outer and the Pembrokeshire South waterbodies. However, these will result in highly localised and low magnitude effects. In addition, the migratory fish species considered in assessment were determined to have low sensitivity, and it was concluded that there is negligible risk across all Project phases. Accordingly, these activities are not expected to jeopardise attainment of the WFD objectives of the Pembrokeshire South or Milford Haven Outer waterbodies.

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Appendix A Offshore Ornithology

Non-ID apportioning

Appendix Table 1: Guillemot, Differences in Unapportioned and Apportioned Population Estimates (uncorrected for availability bias)

Survey	Unapportioned population estimate	Apportioned population estimate	Difference
22-Oct-19	5,853	6,288	435
08-Nov-19	980	1,017	37
04-Dec-19	1,290	1,444	154
18-Jan-20	507	504	-3
04-Feb-20	140	160	20
03-Mar-20	334	354	20
04-Apr-20	153	153	0
08-Jun-20	63	63	0
24-Jun-20	409	433	24
23-Jul-20	463	507	44
31-Aug-20	17,302	18,176	874
12-Sep-20	4,456	4,728	272
15-Oct-20	5,222	5,436	214
22-Nov-20	4,243	4,311	68
31-Dec-20	1,355	1,403	48
16-Jan-21	1,734	1,833	99
22-Feb-21	538	616	78
05-Mar-21	5,053	5,537	484
10-Apr-21	606	626	20
14-May-21	864	865	1
15-Jun-21	506	520	14
14-Jul-21	153	165	12
16-Aug-21	39	38	-1
01-Sep-21	47	53	6

Appendix Table 2: Razorbill, Differences in Unapportioned and Apportioned Population Estimates (uncorrected for availability bias)

Survey	Unapportioned population estimate	Apportioned population estimate	Difference
22-Oct-19	1,799	1,971	172
08-Nov-19	420	432	12
04-Dec-19	86	95	9
18-Jan-20	59	60	1
04-Feb-20	8	9	1
03-Mar-20	39	46	7
04-Apr-20	136	137	1
08-Jun-20	0	0	0
24-Jun-20	4	5	1
23-Jul-20	12	14	2
31-Aug-20	62	78	16
12-Sep-20	98	109	11
15-Oct-20	227	335	108
22-Nov-20	89	104	15
31-Dec-20	507	530	23
16-Jan-21	694	727	33
22-Feb-21	67	64	-3
05-Mar-21	109	121	12
10-Apr-21	24	24	0
14-May-21	32	38	6
15-Jun-21	8	12	4
14-Jul-21	0	0	0
16-Aug-21	0	0	0
01-Sep-21	0	0	0

Appendix Table 3: Puffin, Differences in Unapportioned and Apportioned Population Estimates (uncorrected for availability bias)

Survey	Unapportioned population estimate	Apportioned population estimate	Difference
22-Oct-19	35	91	56
08-Nov-19	0	0	0
04-Dec-19	8	11	3
18-Jan-20	0	0	0
04-Feb-20	0	0	0
03-Mar-20	8	8	0
04-Apr-20	774	830	56
08-Jun-20	0	0	0
24-Jun-20	347	397	50
23-Jul-20	4	4	0
31-Aug-20	16	49	33
12-Sep-20	4	16	12
15-Oct-20	0	0	0
22-Nov-20	0	0	0
31-Dec-20	0	0	0
16-Jan-21	0	0	0
22-Feb-21	0	0	0
05-Mar-21	20	57	37
10-Apr-21	75	97	22
14-May-21	163	207	44
15-Jun-21	430	478	48
14-Jul-21	20	27	7
16-Aug-21	8	12	4
01-Sep-21	8	8	0

Appendix Table 4: Kittiwake, Differences in Unapportioned and Apportioned Density Estimates

Survey	Unapportioned density estimate	Apportioned density estimate	Difference
22-Oct-19	1.4	1.43	0.03
08-Nov-19	6.97	6.83	-0.14
04-Dec-19	1.37	1.37	0
18-Jan-20	0.35	0.33	-0.02
04-Feb-20	0.78	0.76	-0.02
03-Mar-20	0.09	0.17	0.08
04-Apr-20	0	0	0
08-Jun-20	0	0	0
24-Jun-20	0.08	0.09	0.01
23-Jul-20	0.09	0.08	-0.01
31-Aug-20	0.34	0.45	0.11
12-Sep-20	0	0	0
15-Oct-20	2.52	2.67	0.15
22-Nov-20	0.61	0.59	-0.02
31-Dec-20	4.17	4.29	0.12
16-Jan-21	11.15	11.1	-0.05
22-Feb-21	0.96	0.87	-0.09
05-Mar-21	0.09	0.08	-0.01
10-Apr-21	0	0	0
14-May-21	0	0	0
15-Jun-21	0	0	0
14-Jul-21	0	0	0
16-Aug-21	0	0	0
01-Sep-21	0	0	0

Appendix Table 5: Lesser black-backed gull, Differences in Unapportioned and Apportioned Density Estimates

Survey	Unapportioned density estimate	Apportioned density estimate	Difference
22-Oct-19	0	0	0
08-Nov-19	0	0	0
04-Dec-19	0	0	0
18-Jan-20	0	0	0
04-Feb-20	0	0	0
03-Mar-20	0	0	0
04-Apr-20	0	0	0
08-Jun-20	0	0	0
24-Jun-20	0	0	0
23-Jul-20	0.61	0.6	-0.01
31-Aug-20	0	0	0
12-Sep-20	0	0	0
15-Oct-20	0	0	0
22-Nov-20	0	0	0
31-Dec-20	0	0	0
16-Jan-21	0	0	0
22-Feb-21	0	0	0
05-Mar-21	0	0	0
10-Apr-21	0	0	0
14-May-21	0	0	0
15-Jun-21	0.86	0.86	0
14-Jul-21	0.18	0.17	-0.01
16-Aug-21	0.17	0.17	0
01-Sep-21	0	0	0

Monthly Population Estimates for the Auks including Non-Identified Birds

Appendix Table 6: Guillemot, population estimates (corrected for availability bias)

Survey	Absolute population estimate	Lower 95% confidence	Upper 95% confidence	Standard deviation	CV (%)
22-Oct-19	14,567	9,243	20,482	1,786	12.26
08-Nov-19	2,356	1,791	3,060	202	8.57
04-Dec-19	3,345	2,697	3,885	184	5.50
18-Jan-20	1,235	968	1,520	85	6.88
04-Feb-20	371	213	519	49	13.21
03-Mar-20	820	484	1,181	112	13.66
04-Apr-20	354	225	470	38	10.73
08-Jun-20	146	69	225	25	17.12
24-Jun-20	1,003	795	1,246	74	7.38
23-Jul-20	1,175	799	1,638	127	10.81
31-Aug-20	42,108	34,692	48,898	2,234	5.31
12-Sep-20	10,953	9,607	12,538	443	4.04
15-Oct-20	12,593	10,925	14,176	518	4.11
22-Nov-20	9,987	8,894	11,027	339	3.39
31-Dec-20	3,250	2,574	4,033	238	7.32
16-Jan-21	4,246	3,598	4,879	201	4.73
22-Feb-21	1,427	1,142	1,784	102	7.15
05-Mar-21	12,827	9,811	17,041	1,179	9.19
10-Apr-21	1,450	1,068	1,826	115	7.93
14-May-21	2,004	1,742	2,319	91	4.54
15-Jun-21	1,205	901	1,527	99	8.22
14-Jul-21	382	208	556	57	14.92
16-Aug-21	88	0	264	49	55.68
01-Sep-21	123	37	225	30	24.39

Appendix Table 7: Razorbill, population estimates (corrected for availability bias)

Survey	Absolute population estimate	Lower 95% confidence	Upper 95% confidence	Standard deviation	CV (%)
22-Oct-19	4,380	2,624	6,427	645	14.73
08-Nov-19	960	667	1,282	103	10.73
04-Dec-19	211	127	309	31	14.69
18-Jan-20	176	56	316	41	23.3
04-Feb-20	20	2	47	8	40
03-Mar-20	102	36	167	21	20.59
04-Apr-20	304	138	469	55	18.09
08-Jun-20	0	0	0	0	0
24-Jun-20	11	2	27	6	54.55
23-Jul-20	31	2	87	17	54.84
31-Aug-20	173	84	289	35	20.23
12-Sep-20	242	133	376	41	16.94
15-Oct-20	744	358	1,211	141	18.95
22-Nov-20	231	127	338	35	15.15
31-Dec-20	1,178	467	2,049	262	22.24
16-Jan-21	1,616	651	2,656	332	20.54
22-Feb-21	142	71	224	27	19.01
05-Mar-21	269	104	484	69	25.65
10-Apr-21	53	11	109	18	33.96
14-May-21	84	29	142	18	21.43
15-Jun-21	27	0	58	8	29.63
14-Jul-21	0	0	0	0	0
16-Aug-21	0	0	0	0	0
01-Sep-21	0	0	0	0	0

Appendix Table 8: Puffin, population estimates (corrected for availability bias)

Survey	Absolute population estimate	Lower 95% confidence	Upper 95% confidence	Standard deviation	CV (%)
22-Oct-19	197	74	392	55	27.92
08-Nov-19	0	0	0	0	0
04-Dec-19	24	0	48	8	33.33
18-Jan-20	0	0	0	0	0
04-Feb-20	0	0	0	0	0
03-Mar-20	17	0	50	10	58.82
04-Apr-20	1,797	1,418	2,204	132	7.35
08-Jun-20	0	0	0	0	0
24-Jun-20	859	602	1,128	91	10.59
23-Jul-20	9	0	26	6	66.67
31-Aug-20	106	50	173	21	19.81
12-Sep-20	35	17	58	8	22.86
15-Oct-20	0	0	0	0	0
22-Nov-20	0	0	0	0	0
31-Dec-20	0	0	0	0	0
16-Jan-21	0	0	0	0	0
22-Feb-21	0	0	0	0	0
05-Mar-21	123	61	208	25	20.33
10-Apr-21	210	130	284	25	11.9
14-May-21	448	232	706	79	17.63
15-Jun-21	1,035	801	1,288	82	7.92
14-Jul-21	58	22	104	14	24.14
16-Aug-21	26	0	63	11	42.31
01-Sep-21	17	0	43	8	47.06

Apportioning Weightings

NRW Advisory and JNCC application responses (21 and 22 April 2022) raise no substantive concerns about the breeding season apportioning undertaken, as applied to SPAs. Appendix Table 9 provides these breeding season apportioning weightings for the range of species at Skomer, Skokholm and Seas off Pembrokeshire SPA and for gannet at Grassholm SPA.

Appendix Table 9: SPA apportioning weightings in the breeding season

Species	SPA	Apportioning weighting (breeding season)
Guillemot	Skomer, Skokholm and Seas off Pembrokeshire	0.754
Razorbill		0.892
Puffin		0.997
Kittiwake		0.817
LBBG		0.978
Gannet	Grassholm	0.995

In their application response (21 April 2022), NRW Advisory advised how they would calculate non-breeding season SPA apportioning weightings. At the meeting held on 28 June 2022, they confirmed that HiDef had interpreted their advice correctly in the 'Ornithology Consultation Clarification Note' and that the calculations provided in that note were correct.

These non-breeding season apportioning weightings have been determined with reference to Furness (2015), the report on biologically defined minimum population scales (BDMPS). The weighting is derived by calculating the proportion of the 'total' BDMPS population (adults and immatures together) represented by the SPA population in question (breeding adults only).

Appendix Table 10 presents these non-breeding season SPA apportioning weightings, as advised by NRW Advisory.

Appendix Table 10: SPA apportioning weightings in the non-breeding season

Species	BDMPS season*	SPA breeding adults in the BDMPS	BDMPS total population	Apportioning weighting (non-breeding)
Skomer, Skokholm and Seas off Pembrokeshire SPA				
Guillemot	Non-breeding Table 63, page 377	29,340	1,139,220	0.026
Razorbill	Autumn migration Table 65, page 380	11,762	606,914	0.019
	Non-breeding Table 67, page 384	3,601	341,422	0.011

Species	BDMPS season*	SPA breeding adults in the BDMPS	BDMPS total population	Apportioning weighting (non-breeding)
	Spring migration Table 65, page 380	11,762	606,914	0.019
Puffin	Non-breeding Table 69, page 388	8,681	304,557	0.029
Kittiwake	Autumn migration Table 50, page 354	1,254	911,586	0.001
	Spring migration Table 50, page 354	1,672	691,526	0.002
Grassholm SPA				
Gannet	Autumn migration Table 48, page 350	78,584	545,954	0.144
	Spring migration Table 48, page 350	78,584	661,888	0.119

*Table references (and figures presented) are to Furness (2015) Appendix A: *Contributions of individual SPA populations and of UK non-SPA populations and overseas populations to each BDMPS.*

Thresholds for PVA

NRW Advisory and JNCC provide advice in their application responses (21 and 22 April 2022) on 'thresholds' to determine whether PVA is needed to further consider the population consequences of estimated mortalities (collision risk / displacement). This is done by applying adult survival rates (*1-survival rate*) to most recent SPA population counts to get a measure of baseline mortality. The advised 1% threshold is then applied to these baseline mortalities to give a gauge on the amount of 'allowable' mortality before PVA should be undertaken.

Appendix Table 11 provides the supporting information for this calculation and the 1% threshold of baseline mortalities thus determined.

Note that more recent SPA population counts may be available for kittiwake and lesser black-backed gull but these have not been obtained as these two species have not been reassessed (as discussed in Section 5.2).

Appendix Table 11: SPA thresholds of significance

SPA protected feature	Adult survival rate*	SPA breeding adults (IND)	Year of census	Baseline mortality (IND)	1% of baseline mortalities (IND)
Grassholm SPA					
Gannet	0.919	72,022	2015	5,834	58
Skomer, Skokholm and Seas off Pembrokeshire SPA					
Guillemot	0.930*	32,122	2021	2,248	22
Razorbill	0.895	11,524	2021	1,210	12
Puffin	0.906	38,342	2018	3,604	36
Kittiwake	0.854	2,472	2018	361	4
LBBG	0.885	12,836	2018-2019	1,476	15

** The adult survival rate is taken from Horswill & Robinson (2015) except for guillemot where the Skomer rate in the NE PVA tool is referenced. Note that for razorbill and puffin the values are the same for each.*

IND = individuals.

Kittiwake and Lesser black-backed gull; Updated Mortality Estimates

Appendix Table 12 presents updated mortality estimates for kittiwake and lesser black-backed gull (LBBG) following NRW Advisory and JNCC recommendations on collision risk and 'worst case' rates of displacement mortality (application responses of 21 and 22 April 2022).

Appendix Table 12 summarises the CRM option 2 outputs for each species for the 14 MW turbine scenario (Volume 3, Technical Appendix 11.3: Collision Risk Modelling). It then also summarises the estimated kittiwake displacement mortalities, based on a 'worst case' 30% displacement rate and 10% mortality rate applied uniformly across breeding and non-breeding seasons (Volume 3, Technical Appendix 11.4: Displacement Analysis).

For displacement, the 30% / 10% rates are applied to the following MSPs for kittiwake:

- breeding season: 2 birds
- autumn migration: 2,022 birds
- spring migration: 508 birds

Where fractions of a bird are recorded the figures are rounded up or down to the closest whole bird, however, the figure of 0.06 kittiwake displacement mortalities in the breeding season has been left unrounded for information.

Appendix Table 12: Updated CRM / displacement mortality estimates for kittiwake and LBBG

Species	CRM Option 2			Displacement		
	Breeding	Autumn migration	Spring migration	Breeding	Autumn migration	Spring migration
Kittiwake	0	9	5	0.06	61	16
LBBG	2	0	0	Not applicable		

For kittiwake, CRM and displacement impacts are summed as 'worst case' as presented in Appendix Table 12 (total mortality estimates). The impacts for each species are then apportioned to Skomer, Skokholm and Seas off Pembrokeshire SPA using the apportioning weightings given in Appendix A.

Appendix Table 13: Apportioning kittiwake and LBBG mortality estimates against SSSoP

Species	Total mortality estimates			Apportioned mortality estimates			
	Breeding	Autumn migration	Spring migration	Breeding	Autumn migration	Spring migration	Annual total
Kittiwake	0.06	70	21	0.05	0.07	0.04	0.16
LBBG	2	0	0	2	0	0	2

Again, figures are rounded up or down to the closest whole bird, however, the kittiwake breeding season mortality and all the SPA apportioned impacts for this species are left unrounded for information.

The annual mortalities for each species as apportioned to Skomer, Skokholm and Seas off Pembrokeshire SPA will not have any measurable impact on the viability of either species' population at the SPA and there will be **no adverse effect on site integrity**.

The thresholds for carrying out PVA against the SPA populations (1% baseline mortality) are 4 kittiwake and 15 LBBG, and the estimated impacts for each species lie well below these thresholds.

Avian influenza

Avian influenza (commonly referred to as 'avian flu' or 'bird flu') is a virus that causes disease in birds, affecting the respiratory, digestive and/or nervous system of many species. Typically, infections are from a low pathogenic viral strain which causes mild illness. However, strains can mutate from, low to high, which cause severe symptoms, often with high mortality rates and may spread quickly causing an outbreak. The virus has become a disease of global significance due to poultry intensification creating conditions favourable for highly pathogenic strains, globalisation of the poultry marked creating pathways of transmission globally and increased domestic-wild bird interactions due to changing land use (Gilbert and Xiao, 2008).

In October 2021, a new strain of highly pathogenic avian flu (H5N1) was identified in the UK. Since then, 120 further locations of infection in captive birds and poultry, have been identified across the UK, and 354 separate locations of infection across wild birds of 63 species have been identified across 76 countries worldwide (DEFRA, 2022). This has been the highest recent occurrence of highly pathogenic avian flu in the UK with 90 cases of outbreak, compared with 28 in winter 2016/17 and 13 in 2020/21 (Lean *et al*., 2022). The greatest proportion of infections has been observed in Anseriformes (swans, geese and ducks) who form a natural reservoir of the virus. Charadriiformes (waders, gulls and auks) and Accipitriformes (hawks, eagles, vultures, and kites) have also observed high occurrences of the 2021/22 avian flu (DEFRA, 2022).

The majority of outbreaks in wild birds in the UK have been recorded in Scotland and the east coast of England, with devastating effects. It is estimated that as many as 64% of great skua on St Kilda and 85% on Rousay have died as of June 2022 (NatureScot, 2022a), and more than 10% at Fair Isle by the end of winter 2021/22 (Banyard *et al*., 2022). Early population estimates for gannet indicate a loss of 15-25% of the species at Bass Rock and Hermaness, Shetland (Martin, 2022). Shortly after observing their first avian flu case on 21 June 2022, a large die off of guillemot was reported at St Abbs Head National Nature Reserve, which included 68 chicks (Hall, 2022). The Isle of May recorded their first cases on 30 June 2022 following testing of two dead kittiwakes (Steel, 2022), with early estimates of 9,120 kittiwake mortalities, and large number of gulls and arctic tern also affected by the outbreak (Steel, *pers comm*. 19 July 2022).

As of 1 August 2022 in Wales, 45 cases of avian flu have been recorded across five locations (DEFRA, 2022). These have predominantly been recorded in Anseriform species, but with three cases in black headed gull, and three cases in herring gull also observed. However, on 3 August 2022, the RSPB confirmed that bird flu has been identified at Grassholm island, after several suspicious gannet deaths occurred (RSPB, 2022). At present, this appears to be a small outbreak but has the potential to escalate, with the disease having only recently reached the colony. As of 9 August 2022, there are no cases of avian flu identified at Skomer or Skokholm islands (Wildlife Trust of South and West Wales, 2022). However, as the islands are close to Grassholm, there is concern that the disease will spread to these nearby colonies.