DBS Offshore Wind

RWE Renewables UK Dogger Bank South (West) Limited

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Dogger Bank South Offshore Wind Farms

Ecological Halo Effects Technical Note

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Glossary

Term	Definition
Array Areas	The DBS East and DBS West offshore Array Areas, where the wind turbines, offshore platforms and array cables would be located. The Array Areas do not include the Offshore Export Cable Corridor or the Inter-Platform Cable Corridor within which no wind turbines are proposed. Each area is referred to separately as an Array Area.
Array cables	Offshore cables which link the wind turbines to the Offshore Converter Platform(s).
Coastal processes	Collective term covering the action of natural forces on the shoreline and nearshore seabed.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Project (NSIP).
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement (ES).
Expert Topic Group (ETG)	A forum for targeted engagement with regulators and interested stakeholders through the EPP.
Evidence Plan Process (EPP)	A voluntary consultation process with specialist stakeholders to agree the approach, and information to support, the Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) for certain topics.
Habitats Regulations Assessment (HRA)	The process that determines whether or not a plan or project may have an adverse effect on the integrity of a European Site or European Offshore Marine Site.
Inter-Platform Cables	Buried offshore cables which link offshore platforms.
Offshore Converter Platforms (OCPs)	The OCPs are fixed structures located within the Array Areas that collect the AC power generated by the wind turbines and convert the power to DC, before transmission through the Offshore Export Cables to the Project's Onshore Grid Connection Points.
Offshore Development Area	The Offshore Development Area for ES encompasses both the DBS East and West Array Areas, the Inter-Platform Cable Corridor, the Offshore Export Cable Corridor, plus the associated Construction Buffer Zones.
Offshore Export Cable Corridor	This is the area which will contain the offshore export cables between the Offshore Converter Platforms and Transition Joint Bays at the landfall.

Term	Definition
Sediment	Particulate matter derived from rock, minerals or bioclastic matter.
Special Area of Conservation (SAC)	Strictly protected sites designated pursuant to Article 3 of the Habitats Directive (via the Habitats Regulations) for habitats listed on Annex I and species listed on Annex II of the Directive
The Applicants	The Applicants for the Projects are RWE Renewables UK Dogger Bank South (East) Limited and RWE Renewables UK Dogger Bank South (West) Limited. The Applicants are themselves jointly owned by the RWE Group of companies (51% stake) and Masdar (49% stake).
The Projects	DBS East and DBS West (collectively referred to as the Dogger Bank South Offshore Wind Farms).

Acronyms

Acronym	Definition
AEoI	Adverse Effect on Integrity
AR	Artificial Reef
DCO	Development Consent Order
EIA	Environmental Impact Assessment
HRA	Habitats Regulations Assessment
MMO	Marine Management Organisation
MPA	Marine Protected Area
OWF	Offshore Wind Farm
RIAA	Report to Inform Appropriate Assessment
SAC	Special Area of Conservation

1 Summary

1. Natural England raised ecological halo effects in their relevant representation [RR-039]. Natural England consider that the Applicants have not undertaken a robust assessment as '*the potential for changes to the physical and/or biological structure and function of Annex I sandbank beyond the footprint of the planned infrastructure'* were not included within the benthic assessments of Dogger Bank South East and Dogger Bank South West ('the Projects') included within the application.

2. In their responses to this issue, the Applicants have highlighted the following key points:

   - The assessment considered the physical and/or biological structure and function in terms of the introduction of hard substrate and subsequent colonisation;
   - It has not been common practice to assess such effects in detail (or as a potential significant effect) in previous offshore wind farm assessment;
   - Following extensive literature review (provided as responses to the examination) that there is limited evidence of any significant effects of the kind described by Natural England; and
   - The lateness of this concern being raised by Natural England in the process, preventing discussion pre-application and inclusion of additional information within the assessment.

3. Natural England maintains their position that there is potential for changes to the 'characteristic communities' of the Dogger Bank SAC from halo effects.

4. The Applicants have therefore provided this document as a comprehensive review of the evidence of halo effects and how these could relate to the Projects. In addition, a methodology for determining the scale of an effect (if it were needed to be quantified) is proposed.

5. The Applicants maintain their position that there is no evidence of significant effects arising from halo effects, but acknowledge that this is a knowledge gap that should be further explored.

2 Introduction

6. Natural England raised ecological halo effects in their relevant representation [RR-039]

   "The Applicant has not considered the potential for changes to the physical and/or biological structure and function of Annex I sandbank beyond the footprint of the planned infrastructure. We are particularly concerned that secondary 'ecological halo' effects could be combined, resulting in broadscale changes in the benthic habitats and communities across the wider DCO area and a significant proportion of Dogger Bank SAC."

7. The Applicants responded in **Response to Natural England's Relevant Representations (Revision 01)** [AS-048] with the following key points:

   - Natural England did not raise this effect pathway pre-Application during either Plan Level or Project Level discussions prior to the Development Consent Order (DCO) application for the Projects, only raising it in examination. Suggesting at this juncture that it is a potential contributor to adverse effect on integrity is not in line with due process; and
   - Notwithstanding the above, a review of the evidence of ecological halo effects showed that results vary widely in terms of the patterns described and the mechanisms proposed to be driving them. Some studies demonstrate enhancements of species richness, abundance or biomass of certain species, whilst other studies demonstrate declines of these benthic characteristic. Some studies show no significant effects at all on benthic infauna or sediments. The evidence is therefore equivocal at best and there is no evidence known of this effect in offshore areas such as the Dogger Bank.
   - Given the lack of evidence of significant effect, it is inappropriate to conclude that there could be adverse effect on integrity from this. It would be more appropriate to use the operational monitoring for the Projects to investigate the effect at Dogger Bank.

8. In **Appendix C2.1 - Natural England's comments and updated advice on Benthic and Intertidal Ecology** [REP2-065], following the above responses Natural England restated its advice that

   "a robust assessment is needed of the potential worst-case area of impact on benthic communities within Dogger Bank SAC sandbank feature, including more detailed assessment of the likely nature and scale of that impact, as a result of changes to physical and biological processes following the placement of structures and cable/scour protection on the seabed."

9. The Applicants therefore undertook further review of the evidence of ecological halo effects from scientific literature as well as from monitoring studies from UK offshore wind farms (where available). This evidence was presented in **The Applicants' Reponses to Deadline 2 Documents (Revision 1)** [REP3-028]. The Applicants maintained their position, and the **Report to Inform Appropriate Assessment (RIAA) Habitats Regulations Assessment (HRA) Part 2 of 4 – Annex I Offshore Habitats and Annex II Migratory Fish (Revision 4)** [REP4-014] was updated with this information. Natural England's position is set out in the **Risk and Issues Log for Deadline 4** [REP4-129]:

"The cumulation of benthic 'ecological halo effect' following the placement of structures on the seabed has not been considered. A robust assessment is needed of the potential Worst-Case area of impact on benthic communities within Dogger Bank SAC sandbank feature, and the nature and scale of that impact, as a result of changes to physical and biological processes following the placement of structures and cable/scour protection on the seabed. Once assessments have been updated, monitoring should be secured via the In principal monitoring plan to determine whether the residual impacts are as predicted."

10. The Applicants consider that the information added to the **RIAA** [REP4-014] should be sufficient to respond to Natural England's request, noting that the **In Principle Monitoring Plan (Revision 4)** [document reference 8.23] has included provision for studying potential halo effects since the application. However, in order to resolve this issue or provide sufficient information for the Examining Authority and Secretary of State to consider should disagreement remain this document provides the following:

- Section 3 - Precedent in UK offshore wind consenting and advice
- Section 4 - Evidence of ecological halo effects (expanding on information previously presented)
- Section 5 - Applicants proposed 'without prejudice' approach to effect quantification
- Section 6 - Survey and Monitoring

3 Precedent in UK Offshore Wind Consenting and Advice to the Projects

3.1 Other Offshore Wind Farms

11. The Applicants have reviewed over 60 Environmental Statements from UK offshore wind farms, from Round 1 to Round 4, the Scottish Territorial Waters Round, Extensions Rounds and ScotWind (covering the period 2001 – 2025). The applicants can find no examples where halo effects (or any other similar terms) were quantified or considered to add to the footprint of effect. Although halo effects were mentioned in the Marine Management Organisation (MMO) monitoring review (MMO, 2014) to the Applicants knowledge this has not translated into consideration within any Environmental Impact Assessment (EIA) / HRA since that report.

12. This review has determined that ecological halo effects / changes to the sediments and communities have only been discussed twice in recent benthic assessments. This was in the Mona Offshore Wind farm and Morgan Offshore Wind Farm environmental statements (ENBW and BP, 2024a, 2024b). This consideration resulted from a pre-application comment from JNCC to the Mona Project (but not to its sister project Morgan, for which the benthic EIA chapter is identical in many respects) (ENBW and BP, 2024a):

"JNCC advised the inclusion of the impact to adjacent habitats from the removal and deposition of marine growth from hard substrates which may potentially impact a larger area than the infrastructure footprint."

13. In these cases, statements are made that there is '*the potential to change the prevailing sediment type in the immediate vicinity of the wind turbines*' and '*recent research by Lefaible et al. (2023) which found that species richness and abundance were both elevated in the immediate vicinity of foundations (37 m from the foundations), but the effect was absent at a distance (350 – 500 m from the foundations)*' (ENBW and BP, 2024a, 2024b). There is no quantification of effects or footprint and the relevant representations and statements of common ground from NRW and JNCC record no issues raised with the approach taken (NRW, 2025, JNCC, 2025, ENBW and BP, 2025a, 2025b).

14. In addition, the Applicants have reviewed all relevant materials and halo effects have not been raised in any relevant representations produced by Natural England in relation to any other Round 4 or Extension projects prior to the Projects application being made.

3.2 Summary of Pre-Application Consideration of Habitat Loss

15. The Projects were the subject of both Plan level and Project level assessment processes. **Table 3-1** summarises the pre-application assessment and consultation opportunities for both processes.

Table 3-1 Pre-application assessment and consultation on habitat loss at Dogger Bank

Assessment stage	Dates	Key Outcomes	Involvement of stakeholders
Plan Level HRA	2021 - 2022	The Crown Estate undertook a Habitats Regulations Assessment (HRA) of the Round 4 plan (The Crown Estate, 2022). This HRA included consideration of the Dogger Bank SAC and found that 'habitat loss' and 'direct damage' from the projects would result in an adverse effect on integrity (AEOI) of the SAC. This assessment was consulted on at draft stage, with an Expert Working Group (EWG) The footprint of 'habitat loss' equated to the worst case footprint of the Projects infrastructure, there was no allowance for any other effect to causing habitat loss. Note that 'direct damage' is equivalent to disturbance in the context of the Project Level assessment. There is no record of Natural England or any other party raising halo effects during the Plan Level HRA process.	The EWG comprised the following bodies: Natural England, MMO, Defra, BEIS, JNCC, NRW, Welsh Government, Department for Agriculture, Environment and Rural Affairs, Northern Ireland, Marine Scotland, RSPB, Nature Scot, TWT, Whale and Dolphin Conservation and The Crown Estate
Plan Level HRA Strategic Compensation	2022 - 2024	Following Round 4, a Round 4 Plan Strategic Steering Group for habitat compensation was formed by The Crown Estate HRA. This group met 13 times between December 2022 and April 2024 to discuss the requirements for benthic compensation for the Dogger Bank SAC. This included discussion of the quantum of compensation required, the quantum based on the footprint of infrastructure from the Projects as per the Plan Level HRA (The Crown Estate, 2022).	The Steering Group consisted of The Crown Estate (with NIRAS as its technical advisor), Natural England; Joint Nature Conservation Committee; Defra; DESNZ; and The Applicants.

Assessment stage	Dates	Key Outcomes	Involvement of stakeholders
		This process and the conclusions are summarised in the **Project Level Dogger Bank Strategic Compensation Plan** [APP-060]. Halo effects or their potential to increase the footprint of habitat loss was not raised by Natural England or any other party during the Strategic Compensation process.	
Project Level Assessment	2021 - 2024	Natural England had the opportunity to raise halo effects at Scoping and Screening (2022), Section 42 statutory consultation (2023) or during any of the ETG consultation (throughout). The Applicants considered the following effects of relevance: • Physical change; and • Introduction or spread of invasive non-indigenous species (INIS) These effects are considered in the worst case assumptions. Table 9-1 (**Chapter 9 Benthic and Intertidal Ecology** [APP-085]) and Table 6-3 (**RIAA** [REP4-014]) assess habitat lost as the worst case of turbine plus scour protection and worst case of unburied protected cable. The footprints are discussed in section 4.2.3. Within the assessment there is an assumption of 100% physical change (i.e. permanent habitat loss) within these footprints. If this scour and cable protection is subsequently colonised there is no further loss of habitat – this footprint was already lost.	Scoping, Screening and S42 were public consultations. Natural England, MMO, TWT, Cefas and Environment Agency all participated in the Expert Topic Group

Assessment stage	Dates	Key Outcomes	Involvement of stakeholders
		If scour protection or cable protection is not required (either in fewer locations, a lower percentage of cables or less scour protection is required at turbines) then the footprint for physical change will be below the worst case. It was clear from the documents provided by the Applicants that the footprint of any impact would be based upon the footprint of infrastructure. No mention of ecological halo effects was made in any response from, or during any discussions with, Natural England.	

3.3 Post-application Advice

16. **Table 3-2** summarises the post-application advice on halo effects.

Table 3-2 Post application advice on halo effects

Reference	Natural England comment	Response
Relevant Representation [RR-039]	The Applicant has not considered the potential for changes to the physical and/or biological structure and function of Annex I sandbank beyond the footprint of the planned infrastructure. We are particularly concerned that secondary 'ecological halo' effects could be combined, resulting in broadscale changes in the benthic habitats and communities across the wider DCO area and a significant proportion of Dogger Bank SAC.	In their responses to this issue, the Applicants have highlighted the following key points: • Following extensive literature review that there is limited evidence of any significant effects of the kind described by Natural England; • That it has not been common practice to assess such effects in detail i(or as a potential significant effect) in previous offshore wind farm assessment; s and • If this was a concern for Natural England pre-application, it should have been raised then so that information could be included within the assessment. Natural England provided two references to support its case (De Borger *et al.*, 2021 and Reeds *et al.*, 2018). These references are discussed in Section 4.1.
REP2-065	Appendix C2.1 - Natural England's comments and updated advice on Benthic and Intertidal Ecology Natural England acknowledges that during pre-application discussions with the Applicant we had not used the specific terminology of an 'ecological halo effect', with this terminology introduced in our Relevant Representation submission. However, we highlight that whilst the terminology had not been used, the impact pathway it describes is not new or unknown. Colonisation of hard structures and/or utilisation of the presence of infrastructure in the water column, can lead to localised changes in biological communities, which combined with changes to physical processes resulting from the presence of the infrastructure, can alter the characteristic composition of the benthic habitat and/or biological	Whilst the statement that 'the impact pathway it describes is not new or unknown' is correct, this does not explain why, if this was considered to be an important effect (potentially contributing to AEOI) it was never raised as an issue in the pre-application stage. Whilst the Applicants were aware of this effect (and included provision for this within the monitoring proposals) given that the effect has never been discussed historically with regard to offshore wind (see section 4.1), or raised in any Project-level consultation directly, the Applicants consider that their assessments were in line with both standard advice and that provided specifically to the Projects, as well as best practice observed over many years. It is the case that Natural England may change advice to respond to new issues, however, by Natural England's own admission the impact pathway it describes is 'not new or unknown'.

Reference	Natural England comment	Response
	community in the surrounding area, creating a halo of changed habitat and ecology.	
	We note the Applicant's assertion that this has not previously been raised during the Evidence Plan Process or with respect to other offshore wind farms (OWF). However, the Applicant's EIA scoping screened in 'Colonisation of introduced substrate', which Natural England assumed would relate to an assessment of the impacts of colonisation on the surrounding habitat. We also consider that it falls under the screened in impact pathways of 'Physical change to another habitat type' and 'Introduction of Invasive and Non-Native Species' (which can include both species non-native to a protected habitat and those nonnative to UK waters). We also highlight that DBS is the only Round 4 project to have array areas wholly within a Special Area of Conservation (SAC) designated for benthic habitat. Further, monitoring the effect of colonisation of OWF infrastructure on the characteristic community of the Dogger Bank SAC is a key component of the Benthic Monitoring Plans for the Dogger Bank A, B, C and Sofia OWFs.	Colonisation-related impacts are covered within **Chapter 9 Benthic and Intertidal Ecology** [APP-085] in section 9.6.3.5 Impact 7 - Colonisation of Introduced Substrate, Including Invasive / Non native Species. The worst case is covered in Table 9-1 and this cross-references Impact 5 – Permanent habitat loss (which equates to 'physical change to another habitat type' in Natural England's response) and this provides the footprint which includes the worst case for scour protection for wind turbines, platforms and unburied cables. This is mirrored in the assessment presented in the **RIAA** [REP4-014] under 6.4.2.6.1 Physical change (to another seabed / sediment type) with the worst case presented in Table 6-3. It is correct that monitoring the effect of colonisation of OWF infrastructure on the characteristic community of the Dogger Bank SAC is included within the monitoring plans for the other Dogger Bank wind farms. Similar provisions have been in the Applicants' **In Principle Monitoring Plan (Revision 4) [document reference 8.23]** since application. In the IPMP it is stated that 'Grab sampling will be designed to capture localised, near-field, far-field and reference sites' during pre- and post-construction surveys which would identify any changes in benthic communities.
	a robust assessment is needed of the potential worst-case area of impact on benthic communities within Dogger Bank SAC sandbank feature, including more detailed assessment of the likely nature and scale of that impact, as a result of changes to physical and biological processes following the placement of structures and cable/scour protection on the seabed.	Natural England has provided no additional advice on how an assessment could be undertaken or any review of evidence (other than the two papers referenced above) to support their case. When asked directly (in a meeting 8th May 2025) for advice on how the footprint of effect could be estimated, Natural England did not provide any guidance other than that they would comments on anything the Applicants provided.

4 Evidence of Ecological Halo Effects

4.1 Studies of the Halo Effect

17. There is potential for fouling communities to develop on turbine towers, scour protection and cable protection, over time. A typical fouling community is shown in **Figure 4-1**.

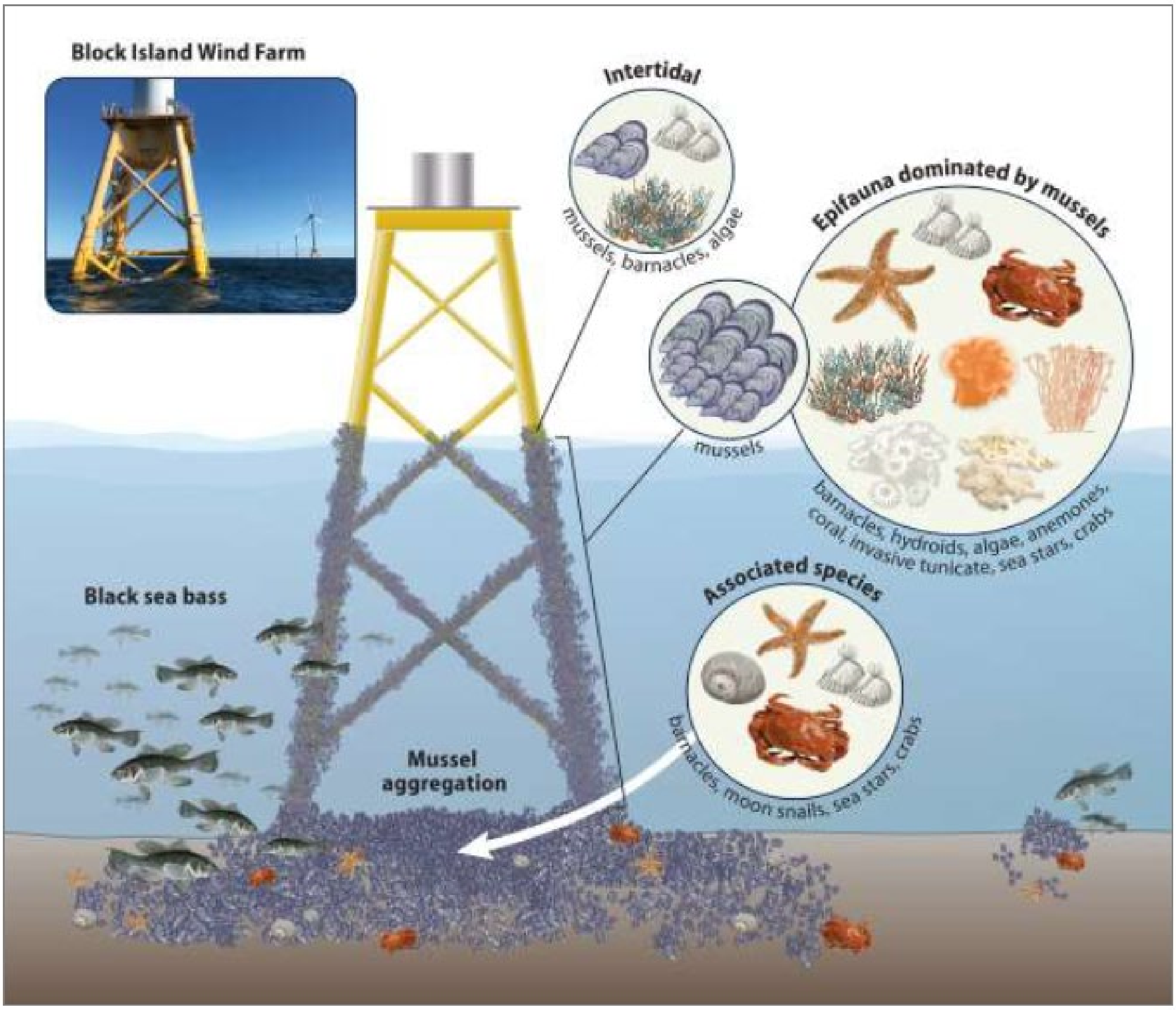

Figure 4-1 Fouling community on jacket foundation (from Hutchison *et al.*, 2020)

18. Organic material from this community will be lost through mortality or effects of currents / storm action meaning that organic matter may be dispersed from the turbine towers, scour protection. There may also be inputs from faeces of sessile species such as mussels.

19. Whilst there will also be colonisation of cable protection, this would not have the potential to develop in scale or complexity as on foundations and towers given this is likely to be only around metre high from the seabed and in small patches.

20. In the case of turbine towers, material being shed will act as per sediment particles, thus it is expected that the heavier material (e.g. aggregations of mussels) will settle rapidly to the seabed, in close proximity of the turbine tower. At Thanet Offshore Wind Farm, heavier material was deposited within 10 – 15m of the foundation (Vattenfall Wind Power Ltd, 2018). This is supported by evidence from Block Island Wind Farm (Hutchison *et al.*, 2020) where operational monitoring shows greatest benthic changes have occurred on or within the footprints of the foundations (four years post installation).

21. Smaller detritus may stay in suspension within the water column for a longer period of time and become advected by tidal currents, diluting any inputs over a wider area. Therefore, not all material that is shed from the turbines towers would be deposited in the immediate vicinity.

22. It is likely that there will be some input of organic material from the turbines, cable and scour protection to the sediments surrounding them. This has been hypothesized to lead to changes in the ecology of those sediments. The following cases come from a review of available literature from comparable locations.

23. Lefaible *et al.* (2019) report different results between jacket and monopile foundations at operational windfarms in Belgium. The C-Power (Thornton Bank) and Belwind (Bligh Bank) locations are environments that are subject to strong physical disturbance where the seafloor typically consists of well-sorted, medium-coarse and mobile sediments with relatively "poor" communities (Lefaible *et al.*, 2019), and so are comparable to the Dogger Bank. In two consecutive years of monitoring (Lefaible *et al.*, 2019), higher fine sand fractions were observed <50m around the jacket foundations and organic enrichment was also observed around the jackets in Year 1 (2017), but not in Year 2 (2018). In contrast, in Year 2, an opposite trend of lower average organic matter content was observed at very close distances around the monopiles. Higher densities and diversity of the benthos in close vicinity of the turbines was reported, which was most pronounced around the jackets, with differences at the monopiles not statistically significant.

24. Breackman *et al.* (2020) continuing the monitoring at C-Power and Belwind in 2019 expected to find that that the locally modified water currents around wind turbines (based on previous finding (e.g. Coates *et al.* (2011) and Lefaible *et al.* (2019), as well as the depositional flow of detritus, would contribute to a process of sediment fining, organic matter enrichment and shifts in macrobenthos community composition, diversity and abundance. Their work, however:

*"**provided equivocal support for this hypothesis**. Sediments 'very close'* [37.5m] *to jacket foundations had a significantly higher proportion of fine sand compared to samples collected at further distance* [350 – 500m], *but this was not accompanied by a higher organic matter content in 2018 and 2019, rather the contrary. Average macrobenthos abundance and diversity were always higher 'very close' to the turbines, **but these differences were not consistently statistically significant**. Macrobenthos species composition, however, did consistently differ between 'very close' and 'far' stations. It also changed significantly with time in the 'very close' stations, a difference which was largely attributable to a pronounced decline in the abundances of three otherwise dominant species....and to an increase of several other species, in particular of the bio-engineering, small reef-building polychaete Lanice conchilega[1]."*

25. De Backer *et al*. (2020 and 2021) also undertook work at C-Power and Belwind, using trawls of the epibenthos over an eight to nine year period. They concluded that (De Backer *et al*., 2020) *"soft sediment epibenthos and fish assemblages in between the turbines underwent no drastic changes due to the presence of the OWFs at mid/ longer term. The assemblages were mainly structured by temporal variability due to changes in temperature and climate indices NAO and AMO [North Atlantic Oscillation and Atlantic Multidecadal Oscillation], and this degree of change is proportionally much larger than the local effect of the present OWF areas."*. They did however find *"some significant secondary effects could be clearly related to the presence of the OWFs pointing to an expansion of the OWF effect beyond the immediate vicinity of the turbine on two fronts: (1) an expansion of the reef effect, and (2) signals of a refugium effect."* This change was related to increased fish densities and was suggested to potentially result from fisheries exclusion and increased food availability (from colonising communities).

26. As well as expected increases hard substrate associated mobile species (such as crabs) increased fish densities of some common soft sediment-associated fish species inside the C-Power wind farm were reported (De Backer *et al.*, 2020). It was considered that this related to a combination of fisheries exclusion and increased food availability. More pronounced effects were found for C-Power than for the more offshore Belwind OWF, highlighting that effects might be site-specific and that extrapolation of these findings to other OWFs should be done with care (De Backer *et al.*, 2020).

27. Lefaible *et al.*, *(*2021) found no significant differences were found between samples taken in close vicinity of the turbine compared to further away (within each habitat type at Norther Wind Farm in first year operational monitoring.

[1] Note that in the UK *L. conchilega* is not considered reef building

28. A study by Li *et al*. (2023), reviewing sample data from offshore wind farms in Belgium, Netherlands, Germany and Denmark concluded from modelling that there are no net adverse impacts during offshore wind farm phase on sandy benthic. They did note, from unpublished data from Belgium, that the biodiversity (it is not clarified how this was measured) of the original soft sediment fauna decreased slightly. The study did not highlight any trawling avoidance benefits (trawling within these wind farms is forbidden) seen within the wind farms, although this was likely due to data constraints.

29. Evidence from Block Island Wind Farm (HDR, 2020, Hutchison *et al.,* 2020) (which included a comprehensive series of diver, grab and video sampling) generally showed no strong gradients of change in sediment grain size, enrichment, or benthic macrofauna in monitoring conducted 4 years after construction in most study locations. The seabed was described as a coarse sediment environment with medium to very coarse sands dominating, with some fines, so is comparable to the Dogger Bank. Notably, the largest changes in communities beyond the footprint of the turbine (at 90m) were seen in the lowest energy study location, which also showed least post-construction recovery. Observed changes in benthic habitats were linked to the mussel dominated colonisation of the structures (HDR, 2020, Hutchison *et al.*, 2020). Li *et al*. (2023), highlight that these results are different from patterns seen in Europe and suggest that different ecoregions and habitat types may have different patterns of change in benthic communities.

30. Monitoring from Beatrice Offshore Wind Farm (Moray Firth) found no mussels colonised its structures (the anemone *Metridium senile* was the dominant colonising species) with little evidence of debris reaching the seabed two years following construction (APEM, 2021). At the base and in the immediate vicinity of the jacket legs, mobile species such as the hermit crab *Pagurus bernhardus*, flatfish, the common sea urchin *Echinus esculentus* and common starfish *Asteria rubens* were recorded suggesting the availability of food in the immediate vicinity of the turbine legs (e.g., pseudofaeces and detritus) although no biological material was recorded on the seabed. Material may be rapidly consumed by organisms or relocated due to tidal currents. There was limited evidence for effects of fouling communities on the epibenthic community composition in the immediate vicinity of the turbines, other than the presence of some mobile species (APEM, 2021). Infaunal monitoring (APEM, 2022) indicated that there has been a shift in the dominant biotope during the second year survey, however, this shift was apparent in the wind farm and at the reference stations. It was concluded that there was no evidence that Beatrice has had an impact on the benthos, and changes were likely due to natural variation (APEM, 2022).

31. Moray East has a range of sandy and coarse sediment biotopes (Moray Offshore Wind Farm (East) Limited, 2024). In post construction monitoring at Moray East (undertaken 2 – 3 years post installation) (Moray Offshore Wind Farm (East) Limited, 2024) no gross changes in benthic habitat types were observed between pre- and post-construction occasions. Significant broadscale habitat alteration was not detected, no evidence of seabed organic enrichment was recorded and no accumulation of biomass from fouling communities was observed (Moray Offshore Wind Farm (East) Limited, 2024). It is noted that survey techniques were acoustic or visual and no grab sampling was undertaken.

32. The MMO reviewed post-construction monitoring reports from 22 Round 1 and Round 2 projects (MMO, 2014) and concluded that to date Offshore Wind Farms (OWFs) have not had significant impacts on the benthic habitats and associated faunal communities. Any observed differences within the impact areas were also recorded within the reference area and, therefore, could be attributed to natural variability (MMO, 2014). The report does however, go on to note that the lack of effects detected could have been due to methodologies used and notes the findings of European studies:

"The non-UK sites have adopted the target issues considered in the UK, i.e. occurrence of non-indigenous species; occurrence and composition of fouling communities and assessments of the biomass. They have also considered impacts potentially related to the peripheral and consequential effects of the turbine colonisation. In the instance of the Belgium part of the North Sea study, apparently clear consequential effects of the colonisation have occurred in the peripheral areas around each turbine, in excess of 50 metres (radius) from the edge of the scour protection system. The Danish studies (Dong, 2006) have identified only small effects around the turbines but have hypothesised the development of a "feeding halo" around the turbines, predicted to occur after the development of a mature biofouling community, which is likely to take in excess of five years. Increased biomass values and their potential exploitation by a range of fish species has been demonstrated in Egmond aan Zee (Bouma and Lengkeek, 2012)"

33. The MMO go on to note in their advice:

"Results of this review exercise indicate that to date OWFs in the UK have not had significant impacts on the benthos (primarily the infauna). However, flaws with regard to survey design, data analysis and interpretation (subtidal and intertidal) have been highlighted in many of the cases reviewed, which make a universal conclusion of no significant impact uncertain. This relates primarily to the epifaunal components of the benthos, rather than the infauna, the latter of which have been relatively uniformly investigated. An area of shortfall has been identified with respect to potential long-term consequences of the turbine colonisation on the wider communities particularly via food web interactions. In small-scale studies in overseas projects, results have demonstrated significant localised changes, with the potential for propagation across the wind farm area and farther afield, as the developments begin to support mature communities on the turbines. This represents an area of uncertainty in the UK studies to date."

34. The Applicants have looked for evidence of colonisation of structures within the Dogger Bank but have not found any information. However, the Applicants commissioned a geophysical survey to look at potential recovery of the seabed following the installation and removal of two met masts which were located in the Dogger Bank Wind Farm zone between 2013 and 2017 in the Dogger Bank B and Dogger Bank C wind farms (see **Met Mast Survey Analysis** [APP-083]). A comparison of pre-installation and post removal geophysical survey data was undertaken. The analysis showed no significant seabed features resulting from the presence of met masts, which had been in place for four years prior to decommissioning, there was no evidence of any gross changes, such as presence of mussel aggregations or shell.

35. Reeds *et al.* (2018) (one of the papers cited by Natural England) looked at halo effects on an artificial reef in Australia. They found a 'halo' effect within 30m of the structure, defined by increased fish abundance and grazing, decreased infauna taxon richness and increased infauna abundance. These spatial patterns in infauna **were not** associated with the measured physico-chemical properties of the sediments, including particle grain size, concentrations of metals or organic carbon. It was considered more likely that the infauna were responding to changes in fish grazing of the benthos.

36. Davis *et al.* (1982) found that there were shallow scour effects to 15m around some artificial reefs in California, the reefs had no measurable effect on sand ripple patterns, grain size, organic carbon or infauna beyond the scoured areas. Although in some cases there were changes to infauna, these were related to foraging fish (Davis *et al.*, 1982). This finding is mirrored in the conclusions of De Backer *et al*. (2020) discussed above.

37. The Applicants note the following from (Reeds *et al.*, 2018) (Applicants' emphasis):

"A number of studies have examined the effects of artificial and natural reefs on surrounding infauna (Ambrose and Anderson, 1990; Barros et al., 2001; Davis et al., 1982; Fabi et al., 2002; Fukunaga and Bailey-Brock, 2008; Posey and Ambrose, 1994; Wilding, 2006; Zalmon et al., 2012, 2014). ***However, results of such investigations are widely variable in terms of the patterns described and the mechanisms proposed to be driving them****.*

38. ***Some studies observe a decline in infaunal abundance and species richness within close distances*** *(e.g. several metres) of the artificial structures (Davis et al., 1982; Wilding, 2006),* ***while others observe enhanced species richness, abundance or biomass of certain species close to the reef*** *(Davis et al., 1982). These effects can also extend over large distances i.e. up to 200 m (Davis et al., 1982).* ***In some cases, no significant effects at all on benthic infauna were detected*** *(Fukunaga and Bailey-Brock, 2008; Zalmon et al., 2012)."*

39. The conclusions highlight that (Reeds *et al.*, 2018):

"Comparisons with other studies has shown that the effects of Artificial Reefs (ARs) on soft sediments can vary depending on the type of structure and location, highlighting a requirement for site specific investigations."

40. The second paper referenced by Natural England, De Borger *et al.*, (2021), was a modelling study and did not utilise measurements made in the field. This modelling showed that the presence of large densities of filter feeding fouling communities on offshore wind turbines caused the displacement and aggregation of organic matter from the water column to sediments. De Borger *et al.*, (2021) state

"modelling studies such as ours generate new hypotheses to validate or falsify in future research on the effects of OWFs on biogeochemistry in the sediment (e.g., do changes in the benthic community around offshore structures affect denitrification rates differently than those modelled as a result of only increased OM deposition and solute availability), and indicate where research should be performed to improve on models"

41. The Applicants consider that the evidence for any significant halo effects in the European examples available is limited, and that the studies referenced by Natural England point to this being an area requiring further research, which is the basis of the MMO monitoring recommendation (MMO, 2014) rather than highlighting deficiencies within the Applicants assessments.

42. Note that Appendix 1: Details of Studies Cited provides a summary of the studies listed above with additional detail on project location, seabed conditions, and foundations.

4.2 Dogger Bank context

4.2.1 Baseline ecology

43. Natural England's Risk & Issues Log Deadline 2, point C8 (see **Natural England's Advice on Benthic and Intertidal Ecology** [REP2-065]) states:

"Colonisation of hard structures and/or utilisation of the presence of infrastructure in the water column, can lead to localised changes in biological communities, which combined with changes to physical processes resulting from the presence of the infrastructure, can alter the characteristic composition of the benthic habitat and/or biological community in the surrounding area, creating a halo of changed habitat and ecology."

44. Whilst there is evidence of 'change' in some of the studies listed in section 3.1, from the comparable situations to Dogger Bank (e.g. Lefaible *et al.*, 2019) the most gross change was from a community typical of well-sorted, medium-coarse and mobile sediment to one with fine to medium sandy sediment. This change was also restricted to the immediate vicinity of the turbine foundations (37.5m) with no evidence of significant change at greater distances (Lefaible *et al.*, 2019). Continuing the monitoring the following year, Breackman *et al.* (2020) found that community differences were not consistently statistically significant.

45. It is important to consider what biotopes are and the range of biotopes across the Dogger Bank SAC.

46. Biotopes are a useful statistical construct whereby the similarity between the content of individual small sediment grab samples (approx. 0.1m^2) often collected at relatively wide spacing (up to 10's of kilometres) is calculated in terms of the number and abundance of infaunal species present and sediment grain size. The degree of similarity between such samples is a judgement and varies with scale. Often samples collected at the same location and time will display significant variation in number and abundance of species. When the distribution and extent of biotopes are mapped, it is necessary to interpolate between individual sample points using additional environmental information such as water depth, broad sediment type and various statistical techniques[2].

[2] The method used for defining UK sediment biotopes by the JNCC is described in Connor et al (2004)

47. When broader scale Annex I habitat types are mapped, such areas can incorporate considerable variation in biological communities present in time and space depending on many factors such as localised variations in sediment type, slope, organic matter content, availability of small scale hard substrates (e.g. pebbles, shells) for attachment and disturbance, larval settlement and recruitment. Such localised variation in small scale community types is characteristic of heterogeneous habitats in naturally disturbed environmental conditions, rather than a physical change to another habitat type at Annex I habitat level. Any change that is potentially occurring as a result of the wind farm therefore needs to be considered in light of the fundamental variability between and within communities even if assigned to the same biotope.

48. The Dogger Bank is a mosaic of different types of sandbank biotopes, based upon gravel, sand and silt sediments, all which are highly variable (in terms of both species composition and abundances) even within biotopes, and all of which are encompassed by the 'Annex I sandbank' habitat. For example, Dogger Bank Creyke Beck (now Dogger Bank A & B) and Dogger Bank Teesside A & B (now Dogger Bank C and Sofia) surveys found very different communities from the Projects, including brittlestar beds, *Lanice conchilega* aggregations and seapen habitat (Forewind, 2013, 2014), and all of these are considered to be encompassed by the Annex I feature. The biotopes recorded in the environmental statements of the Dogger Bank wind farms are presented in **Table 4-1**. It can be readily seen that the biotopes are variable between the wind farms (with only one biotope found at all wind farms). All of this variation is found within the 'Characteristic communities' of the Dogger Bank SAC and is reflected in the narrative on characteristic communities within the Supplementary Advice on the Conservation Objectives for Dogger Bank SAC (JNCC, 2022).

Table 4-1 Comparison of biotopes recorded in the Dogger Bank wind farm environmental statements (Forewind, 2013 & 2014, [APP-085])

Biotope	Description	Notes
Dogger Bank Creyke Beck (now Dogger Bank A & B)		
SS.SMx.OMx.PoVen	Polychaete-rich deep Venus community in offshore mixed sediments.	
SS.SSa.IMuSa.FfabMag	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand.	Dominant biotope in OWF
SS.SMu.CSaMu.LkorPpel	*Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud.	Dominant biotope in OWF
SS.SSa.IFiSa.NcirBat	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand.	
SS.SSa.IMuSa.FfabMag	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand	

Biotope	Description	Notes
SS.SMx.CMx.FluHyd	*Flustra foliacea* and *Hydrallmania falcata* on tide swept circalittoral mixed sediment.	
SS.SSa.CFiSa.ApriBatPo	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand.	**Only biotope found in all OWFs**
SS.SSa.IMuSa.FfabMag	Part of mosaic with above	
SS.SSa.CFiSa.EpusOborApri	*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand.	
SS.SMx.OMx.PoVen	Polychaete-rich deep *Venus* community in offshore mixed sediments	
SS.SMx.CMx.MysThyMx	*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment	
Dogger Bank Teesside (now Dogger Bank C & Sofia)		
SS.SSa.CFiSa.ApriBatPo	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	Dominant biotope in OWF **Only biotope found in all OWFs**
SS.Ssa.CFiSa	Circalittoral fine sand	Dominant biotope in OWF
SS.SMx.CMx	Circalittoral mixed sediment	
SS.SSa.IMuSa.EcorEns	*Echinocardium cordatum* and *Ensis* spp. in lower shore or shallow sublittoral muddy fine sand	Dominant biotope in OWF
SS.SCS.CCS.MedLumVen	*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel	
SS.SMx.CMx.OphMx	*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment	
SS.SCS.ICS.SLan	Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand	Dominant biotope in OWF
SS.SSa.CMuSa.AbraAirr	*Amphiura brachiata* with *Astropecten irregularis* and other echinoderms in circalittoral muddy sand	
SS.SMu.CFiMu.SpnMeg	Seapens and burrowing megafauna in circalittoral fine mud	
Dogger Bank South		
SS.SSa.IFiSa.NcirBat	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	Dominant biotope in OWF

Biotope	Description	Notes
CR.MCR.SfR.Pid	Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	
SS.SCS.CCS.Blan	*Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel	
SS.SSa.CFiSa.ApriBatPo	*Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand	**Only biotope found in all OWFs**
SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	

4.2.2 Other trends

49. Construction and operation of the Projects will be taking place in a situation where the cessation of fishing via bottom-towed fishing gear has been in place for many years. The Dogger Bank SAC (Specified Area) Bottom Towed Fishing Gear Byelaw 2022, was enacted to protect the entirety of the Dogger Bank SAC from the impacts of bottom-towed fishing gear, and therefore impacts from fishing will be significantly reduced as long as the byelaw remains in place. There is no clear understanding of how the cessation of bottom-towed fishing will affect the communities of the Dogger Bank and what 'recovery' will mean for community composition, the trajectory or speed of any change. As stated in the **RIAA** [REP4-014], fisheries impacts were considered to have affected over 70% of the SAC area annually.

50. A reduction in disturbance (in both scale, intensity and frequency) across the area is likely to lead to significant changes in ecology of the Dogger Bank SAC over time from the current baseline conditions. It is likely in the medium term that these would not mean a change from Annex 1 sandbank (although historically (i.e. prior to industrial fishing) areas of the Dogger Bank included oyster reefs (which would qualify as Annex 1 reef (ABPMer, 2021).

51. It is also worth highlighting that potential habitat change or reef effects are not universally considered as negative consequences. In particular there have been active initiatives in the Netherlands to look at promoting these effects in recognition not only of the degraded nature of the 'baseline' seabed conditions but also seeking to understand the potential for carbon sequestration. At Hollandse Kust West wind farm the project is planning to install 'tree reefs' and 'oyster hubs' (Ecowende, 2025). As part of the IJmuiden Ver zone (2024) licencing round in the Netherlands, the Dutch required bidders to include proposals for nature enhancement going beyond the fouling of infrastructure to actively promoting the introduction of additional structures within wind farms. For example, Noordzeker plans to install artificial reefs at over 75% of the turbines in their project (Noordzeker, 2024, SSE, 2025). This is Although the IJmuiden Ver zone is not within any designated sites, it is adjacent to the Bruine Bank Special Protection Area (and candidate SAC for sandbanks).

52. In addition, outside the UK section of the Dogger Bank, there is an initiative to 'rewild' the Dogger Bank through the reintroduction of horse mussel reef (Doggerland, 2025). Note that the German or Dutch sections of Dogger Bank are, like the UK, only designated for sandbanks, reef is not included as a feature (Eunis, undated a, b). There is therefore not a consensus on the interpretation of what constitutes acceptable or desirable change across different jurisdictions interpreting the same legal requirements.

4.2.3 Effects of the Projects

53. Following installation of foundations, scour protection and cable protection, above seabed infrastructure would be colonised. It may be expected that the turbines are colonised by mussels or potentially anemones, algae and encrusting invertebrates (as per the examples cited in section 3.1). The turbines would provide the greatest opportunity for colonisation of the tower (from seabed to sea surface) and on any scour protection – in the worst case scenario this would be (see Table 6-3 in the **RIAA** [REP4-014] and **Environmental Statement Chapter 5 – Project Description (Revision 3)** [REP1-009], footprints relevant to infrastructure within the Dogger Bank SAC):

- Turbines
  - Towers up to 40m above seabed
  - 11m diameter piles
  - 63m diameter scour protection
  - Worst case seabed footprint
    - Total worst case turbine foundation area, including scour protection – 623,449m² (200 small turbines x 3,117m² total area per turbine)
    - Total worst case offshore platforms foundation area, including scour protection – 16,233m² (3 monopiles x 5,411m² total area per platform

54. Critically, the minimum gap between turbines would be 830m, so even based on the greatest effect range seen there is no interaction between turbines.

55. In contrast, the potential for colonisation of cable protection, though more extensive in seabed footprint, would be more limited as the height above the seabed would only be 1-1.4m (see Table 6-3 in the **RIAA** [REP4-014] and **Environmental Statement Chapter 5 – Project Description (Revision 3)** [REP1-009], footprints relevant to infrastructure within the Dogger Bank SAC):

- Cable protection
  - Height 1 – 1.4m
  - Maximum extent 400m x 15.2m
  - Worst case seabed footprint
    - Total area of array and inter-platform cable protection – 901,160m² (653,400m² array cable protection + 247,760m² inter-platform cable protection

56. Although there will be fouling of the cable protection, it is not apparent that this effect has been looked at in any of the previous studies, with the focus on large structures. However, given the limited effects for large structures noted in the literature review in section 3.1, on balance it is considered that such fouling would not produce sufficient detritus or impact local physical processes sufficiently to result in any measurable halo effect.

57. For the turbines, organic material from the fouling community will be lost through mortality or effects of currents / storm action meaning that organic matter may be dispersed from the turbine towers and scour protection. There may also be inputs from faeces of sessile species such as mussels. As discussed above smaller detritus will advected by tidal currents away from the foundation, thus inputs will be diluted over a wider area, and it is likely that heavier material shed would be deposited on the scour protection (or within the area assessed for habitat loss if no scour protection is deployed) in line with the findings of Thanet Offshore Wind Farm (Vattenfall Wind Power Ltd, 2018) and Block Island (Hutchison *et al.*, 2020) (see paragraph 16).

58. This footprint is already accounted for within the footprint for physical change (Table 9-1 of **Chapter 9 Benthic and Intertidal Ecology** [APP-085]) and Table 6-3 of the **RIAA** [REP4-014]).

59. From a review of the evidence for halo effects in section 3.1 it is considered unlikely that significant changes to the sediments or benthos would occur outwith the permanent change from the footprint of infrastructure. Whilst ranges for change have been hypothesised, the recent evidence suggests that in European scenarios and in sediments similar to the Dogger Bank there would be no effect (APEM, 2021, 2022; Moray Offshore Wind Farm (East) Limited, 2024) or effects would be limited to the immediate vicinity (<50m) from the foundations (Lefaible *et al.*, 2019, De Backer *et al.*, 2020, Breackman *et al.*, 2020, Li et al., 2023). The most relevant non-European examples, from Block Island showed significant changes out to 90m, however this was a coastal location (within 4.5km of shore) in relatively sheltered waters (HDR, 2020, Hutchison *et al.*, 2020). The Applicants consider that any such changes would be difficult to detect (for the reasons explained in section 3.2.1 and 3.2.2) and at worst this would represent a change from one Annex 1 sandbank biotope to another Annex 1 sandbank biotope, which is likely already present in the area. It would not represent a loss of Annex 1 habitat or contribute to any conclusion of adverse effect on integrity.

60. Another effect that has been mentioned in the literature was the potential for increases in fish within warms farms due to reef or refugia effects. This has been hypothesised in Belgium (see De Backer *et al.*, (2020) above) however this has been in conditions where fishing is not permitted in wind farms by law, therefore there is a possible confounding effect of a lack of fishing affecting abundance rather than the wind farm itself being the cause. As discussed in **Chapter 10 Fish and Shellfish Ecology** [APP-091] (section 10.6.2.5) although there is currently a ban on bottom-towed fisheries within the SAC, there is no barrier to other fisheries operating and impact is anticipated to not result in any effect with no change noticeable from natural variation.

4.3 Conclusions

61. Natural England's position is set out in the Risk and Issues Log for Deadline 4 [REP4-129]:

"The cumulation of benthic 'ecological halo effect' following the placement of structures on the seabed has not been considered. A robust assessment is needed of the potential Worst-Case area of impact on benthic communities within Dogger Bank SAC sandbank feature, and the nature and scale of that impact, as a result of changes to physical and biological processes following the placement of structures and cable/scour protection on the seabed. Once assessments have been updated, monitoring should be secured via the In principal monitoring plan to determine whether the residual impacts are as predicted."

62. In response to these points from the literature reviewed:

- Nature of the impact – there are unlikely to be gross changes to the sediment or benthos, which result in a fundamental change of the structure and function of the sandbank communities.
- Nature of the impact – given that fisheries will likely continue within the Array Areas (only bottom towed fishing gear is prohibited by the bye-law, see section 4.2.2) it is considered that there would not be noticeable changes in the fish communities;
- Scale of the impact – any effect (which we consider will be trivial and neither significant in EIA terms nor lead to adverse effect on integrity in HRA terms) is likely to be limited to the immediate vicinity of foundations with a potential maximum extent of <50m.
- **In Principle Monitoring Plan (Revision 4)** [document reference 8.23] includes measures which would identify any changes in benthic communities.

63. The Applicants therefore consider that there is no evidence that there will be significant changes to the characteristic communities of the Dogger Bank SAC from ecological halo effects. The Applicants consider that the correct approach to this knowledge gap is to address it through carefully designed survey and monitoring as included in the IPMP (see section 6).

64. Notwithstanding the above position, section 5 provides an estimate of footprint of effect (on a without prejudice basis) should the Secretary of State consider that ecological halo effects do contribute to adverse effect on integrity and require compensation. Note that this methodology is the Applicants own and that Natural England has not provided advice on how this footprint could be determined, other than that it needs to be 'site-specific' (advice provided in meeting 8th May 2025).

5 Applicants proposed 'without prejudice' footprint

65. As discussed in paragraph 55 although there will be fouling of the cable protection, on balance it is considered that such fouling would not produce sufficient detritus or impact local physical processes sufficiently to result in any measurable halo effect. Therefore, the Applicants propose that cable protection is not included within this 'without prejudice' footprint.

66. The proposed footprint therefore results from the turbines and platforms, their foundations and scour protection. All numbers presented are derived from Table 6-3 in the **RIAA** [REP4-014] and **Environmental Statement Chapter 5 – Project Description (Revision 3)** [REP1-009].

67. Table 5-1 shows the footprint of the worst case turbines (200 x 11m diameter monopile, 63m diameter scour protection) and platforms (three x 15m diameter monopile, 83m diameter scour protection). This provides the base case footprint of the foundations on the seabed, to which are added a series of 'halos' from 10m to 100m to illustrate potential effect footprints. This provides an envelope which covers the highest recorded effect range (i.e. 90m at Block Island (HDR, 2020, Hutchison *et al.*, 2020)). The footprint of the base case (i.e. the permanent habitat loss assuming no halo effect) is then subtracted from the total footprint to determine the additional halo footprint.

Table 5-1 Illustration of halo footprints (assuming 100% coverage and a circle)

Scenario	Radius (m)	Footprint per unit (m^2)	Total footprint (m^2)	Additional footprint (over base case) (km^2)
		Turbine		
			x 200	
Base case foundation + scour protection (no halo)	31.5	3,117.65	623,529.90	n/a
Plus 10m halo	41.5	5,411.31	1,082,261.90	0.46
Plus 20m halo	51.5	8,333.37	1,666,673.90	1.04
Plus 30m halo	61.5	11,883.83	2,376,765.90	1.75
Plus 50m halo	**81.5**	**20,869.95**	**4,173,989.90**	**3.55**
Plus 100m halo	131.5	54,332.25	1,0866,449.90	10.24

Scenario	Radius (m)	Footprint per unit (m²)	Total footprint (m²)	Additional footprint (over base case) (km²)
Platforms				
			x 3	
Base case foundation + scour protection (no halo)	41.50	5,411.31	16,233.93	n/a
Plus 10m halo	51.50	8,333.37	25,000.11	0.01
Plus 20m halo	61.50	11,883.83	35,651.49	0.02
Plus 30m halo	71.50	16,062.69	48,188.07	0.03
Plus 50m halo	**91.50**	**26,305.61**	**78,916.83**	**0.06**
Plus 100m halo	141.50	62,909.91	188,729.73	0.17

68. From the review, the Applicants consider that the worst case halo, would extend to around 50m from a foundation. This would give a total area within which halo effects could be occurring of 3.61km².

69. However, the Applicants do not consider it likely that there would be 100% habitat change (given patchiness of change seen for example at Block Island (HDR, 2020, Hutchison *et al.*, 2020). In addition, changes are most likely to be related to physical process effects. Tidal wake effects can enhance bed shear stress at the seabed which can modify seabed morphology (in the absence of scour protection) and sediment composition (McCarron *et al.*, 2019). Changes to bed shear stress due to tidal wake effects were modelled and the results are presented in **Appendix 8.3 Marine Physical Processes Modelling Technical Report** [AS-135] (illustrated in **Figure 5-1**). Over a 30-day simulation period that includes multiple tidal cycles, the predominant changes in bed shear stress occur to the north-west of the foundations, aligned with the tidal currents.

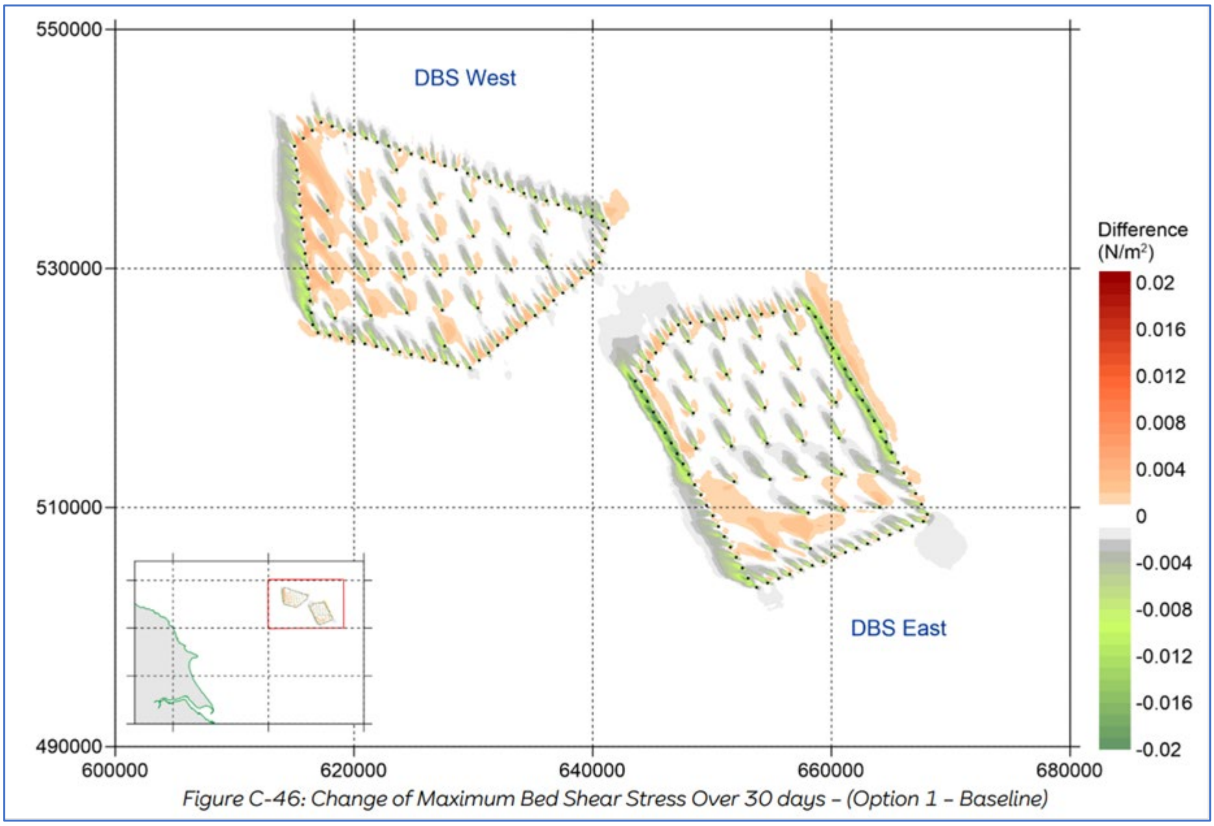

Figure 5-1 Changes to bed shear stress due to tidal wake effects at DBS (modelling presented in Appendix 8.3 Marine Physical Processes Modelling Technical Report [AS-135]

70. If halo effects were to occur, they would most likely be within the area where tidal wakes could influence bed shear stress and therefore it is proposed that habitat change would represent 25% of the total (approximating to the north west quadrant of the halo defined above potentially affected by bed shear stress).

71. **This would therefore be an additional habitat loss of 0.9km².**

72. However, the location of this habitat loss needs to be considered. This would occur in the immediate surrounding of the foundations. This is the same area that would be subject to disturbance during construction (and some on-going disturbance throughout the project life from operation and maintenance activities). Table 6-3 in the **RIAA** [REP4-014] estimates the footprint of this area at 2.54km². It is Natural England's position that this area, will not recover quickly and that this is effectively treated as permanent habitat loss, with 100% of the area contributing to the footprint requiring compensation. In this case, if the Secretary of State concludes that disturbance does contribute to adverse effect on integrity, then the whole area covered by halo effects would already be encompassed. In which case there would be no additional footprint to compensate[3].

[3] Note that even if halo effects went to 100m, with all other assumption the same, the footprint would be 2.6km² in total and still and 98% would remain within the disturbance footprint

73. It is the Applicants' case (as discussed in the **RIAA** [REP4-014] and detailed in **Review of Evidence on Recovery of Sandbank Habitat Following Habitat Damage (Revision 2)** [REP3-021]) that disturbance is temporary and should not contribute to adverse effect on integrity. In this case, if the Secretary of State concludes that halo effects are occurring and result in habitat loss, but agrees with the Applicants that disturbance is temporary, then the additional habitat loss of 0.9km^2 would need to be added to the permanent habitat loss total.

74. Note that any compensation required would be delivered through the agreed strategic compensation measure (i.e. designation on a new marine protected area (MPA) or extension of existing MPA), see **Project Level Dogger Bank Compensation Plan - Volume 6 (Revision 3)** [REP4-028] for further details.

6 Survey and Monitoring

75. The Applicants consider that the best way of addressing the knowledge gap in this case is through carefully planned survey and monitoring.

76. The **In Principle Monitoring Plan (Revision 4)** [document reference 8.23] highlights that monitoring should take account of the set of broad benthic monitoring objectives which Natural England and the Joint Nature Conservation Committee have produced. These cover the conservation objectives for the Dogger Bank SAC and can be applied to developments across the Dogger Bank Zone. These objectives are:

- Objective 1: Determine the impacts on and recovery rates of sandbank physical features affected by wind farm installation, including large and fine scale topography, sediment composition and distribution;
- Objective 2: Characterise and identify impacts on benthic biodiversity and community structure as a result of windfarm installation, i.e. changes in abundance, composition and distribution of native communities;
- Objective 3: Determine the impacts of hard substrate infrastructure introduction on sedimentary benthic communities; and
- Objective 4: Assess the impact of Objectives 2 and 3 on the wider community and structure i.e. linked receptors groups including epifauna, fish and birds.

77. Objectives 2 – 4 directly relate to potential halo effects (and (4) reef or refugia effects).

78. The Applicants do not propose detailed methods at this time. As stated in the **In Principle Monitoring Plan (Revision 4)** [document reference 8.23], proposals for monitoring should be based, as a starting point, on the best practice and outcomes of the latest review of environmental data associated with post-consent monitoring of licence conditions of Offshore Wind Farms (MMO, 2014) and applying more recent best practice guidance and lessons learnt (including from the existing Dogger Bank A, B and C and Sofia programmes) where relevant.

7 References

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Appendix 1: Details of Studies Cited

Project, Location	Sediment type	Depth (m)	Distance from shore (km)	Author(s)	Turbine number & size (if known)	Foundation type	Sample locations
Belwind, Bligh Bank, Belgium	Mobile, medium coarse sediments and low organic matter content	15 - 37	46	Lefaible, et al 2019 Braeckman et al (2020, 2021) De Backer et al (2020, 2021)	33 x 3MW, 1 x 6MW	Monopile	Grab sampling: Near (37.5m) Far (300- 500m) Epibenthic trawls
C-Power Thorton Bank, Belgium	Mobile, medium coarse sediments and low organic matter content	14 - 28	30	Lefaible, et al 2019 Braeckman et al (2020, 2021) De Backer et al (2020, 2021)	54 x 5 – 6MW	Jacket	Grab sampling: Near (37.5m) Far (300- 500m) Epibenthic trawls
Norther, Belgium	Medium sands (not sandbank)	20-35	23	Lefaible, et al 2021	44 x 8.4MW	Monopile	Grab sampling: Near (37.5m) Far (300- 500m)

Project, Location	Sediment type	Depth (m)	Distance from shore (km)	Author(s)	Turbine number & size (if known)	Foundation type	Sample locations
	'high organic content						Epibenthic trawls
Block Island, Rhode Island, USA	Coarse-medium sand, with boulders, cobble, and gravel	30	4.5	Hutchison et al 2020	5 x 6MW 24m cross section	Jacket	Grab sampling and visual out to 90m
South Head, Sydney Harbour, Australia	Flat sandy	38	1.5	Reeds et al, 2018	n/a single artificial reef 12 x 16 x 12m	Lattice structure	Sampling out to 240m
Thanet, Outer Thames Estuary	Chalk bedrock, sand	14 - 23	11	Vattenfall Wind Power Ltd. (2018)	100 x 3MW 4 – 5m	Monopile	DDV of foundations only Reference to deposition of fouling detritus
Beatrice, Morray Firth	Gravelly sand	35 - 68	13	APEM (2022a, b)	84 x 7MW 24 x 24m	Jacket	ROV/DDV 50m transects

Project, Location	Sediment type	Depth (m)	Distance from shore (km)	Author(s)	Turbine number & size (if known)	Foundation type	Sample locations
							Single grab @ WTG and reference stations
Moray East, Moray Firth	Gravelly sand	57	22	Moray Offshore Windfarm (East) Limited (2024)	100 x 9.5MW Max base width 30m	Jacket	MBES collected from within 270m² boxes centred on the turbine foundations. ROV within box
Dogger Bank Met mast	Gravelly sand	25	140 - 200	Applicants [APP-083]	15m	Suction caisson	1 x 1km SSS & SBP

RWE Renewables UK Dogger Bank South (West) Limited

RWE Renewables UK Dogger Bank South (East) Limited

Windmill Business Park
Whitehill Way
Swindon
Wiltshire, SN5 6PB