Triton Knoll Offshore Wind Farm Limited

Environmental Statement
Volume 2: Chapter 3 – Benthic Ecology

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<table>
<thead>
<tr>
<th>Drafted By:</th>
<th>RPS</th>
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<tbody>
<tr>
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<td>20th January 2012, TB.</td>
</tr>
</tbody>
</table>

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3 Benthic ecology

Introduction

3.1 This chapter of the Environmental Statement (ES) describes the benthic subtidal ecology within the Triton Knoll Offshore Wind Farm (TKOWF) site and surrounding areas and is supported by the characterisation report (Volume 3: Annex E). The impact assessment takes into account the guidelines specifically developed for marine and coastal projects by the Institute of Ecology and Environmental Management (IEEM, 2010), and therefore deviates from the standard ES methodology as described in Volume 1: Chapter 5.

Consultation and scoping

3.2 Consultation was undertaken with statutory authorities to agree the scope of the benthic ecology surveys of the TKOWF site. Subsequently consultation focused on the issues and methods to be assessed in the EIA. Statutory authorities were the Marine Management Organisation (MMO), the Joint Nature Conservation Committee (JNCC), Natural England (NE) and the Centre for Environment, Fisheries and Aquaculture Science (Cefas). Consultation was also undertaken under the requirements of the IPC (S42 and S47 of the Planning Act, 2008).

3.3 A summary of consultation and scoping responses which related specifically to the assessment of potential impacts on benthic ecology is provided in Table 3.1 together with where in the chapter these concerns have been addressed.

Table 3.1 Summary of consultation and scoping responses specifically relating to the assessment of impacts on benthic ecology

<table>
<thead>
<tr>
<th>Consultee, document and date</th>
<th>Consultation summarised comment</th>
<th>Section where comment is addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>JNCC/NE (email 28th June 2010) in response to a meeting on 11th March and subsequent supply of EcIA method statement (March 2010) and impacts to be assessed for benthic ecology, and fish and shellfish ecology.</td>
<td>Agreed with proposed assessment methodology. Suggest combining county and district levels to local and reference to marine plan areas for local. Advised that scour and cable protection should also be assessed. Assessment should also include impacts of physical injury and death of species.</td>
<td>Para 3.9 Figure 3.2 Table 3.4</td>
</tr>
<tr>
<td>JNCC/NE (email 6th August 2010) in response to drop down video data supplied for TKOWF)</td>
<td>Agreed that there was no Sabellaria spinulosa or Mytilus edulis reef at any of the sampling stations within the TKOWF site in 2008 based on video footage. An area of stony reef at Station 23 was noted and should be avoided during development.</td>
<td>Para 3.91</td>
</tr>
<tr>
<td>IPC, MMO and JNCC/NE (IPC Scoping Opinion (September 2010))</td>
<td>Colonisation of turbines leading to increased biodiversity should be assessed in the ES including consideration of species being able to artificially extend their range; the ‘stepping stone’ theory.</td>
<td>Table 3.4</td>
</tr>
</tbody>
</table>

IPC (IPC Scoping Opinion (September 2010)) Loss of seabed habitat caused by the presence of turbines should be assessed. | Table 3.4 |

MMO (IPC Scoping Opinion (September 2010)) The interpretative technical report for benthic ecology should be appended to the ES including a drawing of survey positions and biotopes. | Volume 3: Annex E |

MMO (IPC Scoping Opinion (September 2010)) The ES should include details of pre and post construction monitoring surveys for assessing potential impacts. | See paragraph 3.107 and 3.108 |

MMO (IPC Scoping Opinion (September 2010)) The EIA should state whether the predicted impacts of construction, operation and decommissioning are high, medium, low or insignificant based the available evidence. | Paragraphs 3.18 – 3.113 |

Response to S42 and 47 Consultation

JNCC, 14th and 19th July 2011 Assessment methodology, such as those relating to significance of impacts and sensitivity scores, should be more clearly defined. | Paragraphs 3.17 - 3.18 |

JNCC, as above The methodology of assigning the magnitude of effect does not follow the methodology outlined in Volume 1: Chapter 5. | Assessment is based on the IEEM method as made clear in Chapter 3. |

JNCC, as above The description of the methodology for assigning sensitivity of receptors should encompass the vulnerability, recoverability and nature conservation value of the receptor. The methodology presented appears to base the sensitivity of the receptor wholly on the conservation value based on designated or notified status. | ES revised; for example see paragraphs 3.17 and 3.18 and Table 3.2. |

JNCC, as above The level of confidence associated with the potential impact on the integrity of the Inner Dowsing, Race Bank and North Ridge SAC has no justification associated with the assessment. The justification is based on empirical evidence; e.g. paragraph

<table>
<thead>
<tr>
<th>JNCC, as above</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Study title</td>
<td>Study description</td>
<td>Study results</td>
</tr>
<tr>
<td>-----------------</td>
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<td>-----------------</td>
</tr>
<tr>
<td>Study 1</td>
<td>Study 1 description</td>
<td>Study 1 results</td>
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<tr>
<td>Study 2</td>
<td>Study 2 description</td>
<td>Study 2 results</td>
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<td>Study 3</td>
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<td>Study 9</td>
<td>Study 9 description</td>
<td>Study 9 results</td>
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<tr>
<td>Study 10</td>
<td>Study 10 description</td>
<td>Study 10 results</td>
</tr>
</tbody>
</table>

Volume 2 – Chapter 3 RWE Npower Renewables Ltd
| MMO | Terminology used to describe the impacts to the benthic environment should consider the impact on the environment as a whole, and not just on impacts to specific species. | Throughout chapter |
| MMO | The EIA should include a table summarising the predicted effects/impacts of the various activities on the benthic environment. | In the absence of significant potential impacts (paragraph 3.110) a table was considered to be unnecessary |

**Survey methodology**

3.4 Information on the benthic environment was initially collected through a desktop review. Information was available at different geographic scales, and included site specific reference data collected in 2004 (EMU, 2005).

3.5 Consequently, further benthic ecology characterisation surveys were undertaken within the zone of potential impact which, consistent with guidance (Cefas, 2004; Cefas, 2002), was delimited by one tidal excursion from the boundaries of the TKOWF site (Table 3.1). Potential reference sites outside this area were also investigated to allow for future comparison during any potential subsequent monitoring programme, if required. Surveys were undertaken during September and October 2008 (See Volume 3: Annex E; paragraph 2.9).

3.6 The surveys were undertaken primarily using a combination of drop down video (DDV) and single 0.1 m² Hamon grab sample at each site. DDV provided information on the epibenthic community and also enabled a method for non-intrusive identification and mapping of potential Annex I habitats; such as biogenic (e.g. *Sabellaria* or *Mytilus*) or geogenic (cobble) reefs.

3.7 In order to describe the benthic infaunal community and sediment composition, the grab samples were sent for laboratory analysis as follows:
   i) particle size analysis (PSA) to BS1377 (Part 2: 9.2/9.4);
   ii) benthic macro-infauna identification and enumeration; and
   iii) benthic macro-infauna biomass; blotted wet weight converted to ash free dry weight (Eleftheriou and Basford, 1989).
Figure 3.1 Benthic ecology sampling locations within the TKOWF study area
3.8 A standard 2 m Cefas (Jennings) beam trawl sampled the epibenthos; excluding areas previously identified in situ from the video surveillance as potential Annex I habitats.

3.9 The desk study identified that heavy metal and polyaromatic hydrocarbons (PAHs) sediment contamination was unlikely at the TKOWF site, hence no sampling was undertaken (Volume 3: Annex E; Appendix 4 - paragraph 2.17) and no further consideration given in this chapter of potential impacts (in the absence of the possibility of a significant effect).

3.10 Multivariate statistical analyses of the benthic infaunal and epifaunal species data and the associated substrata were used to classify the data into different community types using the statistical package PRIMER (Clarke and Warwick, 2001). Subsequently, each community type was assigned a biotope code (Connor et al., 2004). The geographic extent of each biotope was interpolated across the survey area using the broad scale sediment types and depth contours identified from the site-specific geophysical survey data (sidescan and swath bathymetry) collected across the TKOWF site; and Admiralty Chart bathymetry data and British Geological Society surficial sediment data extending across the wider survey area to assist in delineating biotope ‘boundaries’.

3.11 Based on an initial review of all sampling sites (Volume 3: Annex E; paragraph 2.15-2.23), 49 locations were also specifically assessed for the potential presence of the Annex I habitats: geogenic (cobble reefs) and biogenic reef (e.g. *Sabellaria* reefs and *Mytilus* reefs), using published guidance on classification of these habitats (Gubbay, 2007; Irving, 2009; Holt et al., 1998).

3.12 Further details on survey methods and data analysis are provided in the baseline characterisation technical report presented in Volume 3: Annex E; paragraph 2.

**Assessment criteria and assignment of significance**

**Resource value**

3.13 The value of ecological features is dependant on their biodiversity, social and economic value within a geographic framework of appropriate reference (IEEM, 2010). The most straightforward context for assessing ecological value is to identify those species and habitats that have a biodiversity value recognised through international or national legislation or through local or national conservation plans (e.g. Biodiversity Action Plans). However, only a very small proportion of marine habitats and species currently fall within the legislative or policy framework and therefore evaluation must also assess value according to the functional role of the habitat or species and its distribution and relative abundance in the area. Features of value have been termed ‘valued ecological resources’ (VER).

**Impact components**

3.14 This ecological impact assessment, which takes into account the IEEM marine guidelines (2010), regarding the following components of environmental impact:

i) magnitude - size or amount of impact, quantitatively if possible;

ii) extent - area over which the impact occurs;

iii) duration - the time over which the impact will last (i.e. time to recovery) - and should be distinguished from the duration of the activity;

iv) temporal scale - permanent or temporary change in the ecology;

v) timing and frequency - coincidence with critical life stages or seasons and time between recurring impacts (as important in terms of ability to recover between impacts);

vi) positive or negative effect;

vii) cumulative effects - consideration of the impacts against a background of other threats and impacts e.g. other proposals, completed projects; natural trends; climate change; and

viii) confidence in predictions - likelihood that an impact will occur as predicted.

**Assessment of significance of impact**

3.15 The assessment of significance of impact is a two stage process involving definitions of magnitude and sensitivity.

**Prediction of the magnitude of impact**

3.16 The magnitude of the impact has been considered in terms of spatial extent, duration, reversibility and timing (seasonality and/or frequency of occurrence). Expert judgment was then employed to consider and evaluate the likely impact on the species/population/habitat identified as a Valued Ecological Receptor (VER). The impact magnitude was then identified from a four point scale according to the potential consequences on the VER as given in Table 3.2.

<table>
<thead>
<tr>
<th>Potential consequence on VER</th>
<th>Magnitude of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>The proposal would affect the conservation status of the site or feature.</td>
<td>Major</td>
</tr>
<tr>
<td>The site or feature’s conservation status would not be affected, but the effect is likely to be significant in terms of ecological objectives or populations. If, in the light of full information, it cannot be clearly demonstrated that the effect will not adversely affect the conservation objectives, then the effect should be assessed as major negative.</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Neither of the above applies, but some minor effect is likely.</td>
<td>Minor</td>
</tr>
<tr>
<td>No observable effect predicted.</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

Note: In each case (other than negligible) the effect may be adverse or beneficial.

**Sensitivity of VER**

3.17 Once the impacts have been characterised, the sensitivity of the ecological receptors to these impacts and the associated environmental changes are then assessed. In this chapter, the important benthic ecological receptors are given as biotopes. Different biotopes have been classified by MarLin\(^1\) on a six-point scale of sensitivity (ranging from

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\(^1\) [http://www.marlin.ac.uk/sensitivityrationale.php](http://www.marlin.ac.uk/sensitivityrationale.php)
very high to not sensitive) taking into account intolerance to change and recoverability from impacts.

**Definition of the significance of impact**

3.18 The overall significance of an impact of a given magnitude depends on the sensitivity of the affected site in question, as shown in Table 3.3.

**Table 3.3 Definitions of the significance of impacts**

<table>
<thead>
<tr>
<th>Magnitude of potential impact</th>
<th>Sensitivity of biotope</th>
<th>Low / Very Low</th>
<th>Not sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>Very high / High</td>
<td>Major</td>
<td>Slight</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Major</td>
<td>Major</td>
<td>Slight</td>
</tr>
<tr>
<td>Minor</td>
<td>Slight</td>
<td>Slight</td>
<td>Slight</td>
</tr>
<tr>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

3.19 The key issues that will arise during the construction (and decommissioning) and operational phases and against which the impact assessment was carried out are described in Table 3.4 and are drawn from a variety of guidance, and comments received during consultation.

3.20 It is noted that NPS EN-3 also includes guidance (summarised in Table 3.5) relating to the biodiversity value of subtidal habitats as well as potential secondary or indirect impacts arising from changes to the physical environment which should also be considered.

3.21 With regard to the IPC’s decision making process, NPS EN-3 highlights a number of points relating to the judgement of an application and in relation to mitigation; these are summarised in Table 3.6.

**Table 3.4 Key environmental changes that may arise during the construction/decommissioning and operation phases and the maximum extent considered**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Potential impact</th>
<th>Maximum extent considered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temporary habitat disturbance from inter-array cables and construction and decommissioning plant (e.g. jack-up barges) and during seabed preparation/clearance</td>
<td>Footprint of inter-array cables and construction vessels (jack-up or anchoring)</td>
</tr>
<tr>
<td></td>
<td>Temporary increase in suspended sediment arising from installation/removal of turbine foundations and cable laying</td>
<td>One tidal excursion</td>
</tr>
<tr>
<td></td>
<td>Sedimentation (smothering) by spoil or sediment plumes released during installation/removal of turbines and cables</td>
<td>One tidal excursion</td>
</tr>
</tbody>
</table>

**Table 3.5 Summary of NPS EN-3 guidance of assessment on benthos and consideration in the TKOWF assessment**

<table>
<thead>
<tr>
<th>Summary of NPS EN-3 guidance on assessment of benthos</th>
<th>TKOWF assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of habitat due to foundation type including associated seabed preparation, scour, scour protection and altered sedimentary processes; Environmental appraisal of all cable routes and installation methods; Habitat disturbance from construction vessels’ legs and anchors; Increased suspended sediment loads during construction; and Predicted rates for subtidal zone recovery from temporary effects.</td>
<td>The assessment has considered each of these potential effects and where possible provided a quantification of the effects along with an assessment of their likely significance, considering each phase of the development process.</td>
</tr>
</tbody>
</table>
Figure 3.2 Regional geographic context of the assessment
Table 3.6 Summary of NPS EN-3 guidance on IPC decision making (and mitigation) in relation to benthos and consideration in the TKOWF assessment

<table>
<thead>
<tr>
<th>Summary of NPS EN-3 guidance on IPC decision making (and mitigation) in relation to benthos</th>
<th>TKOWF</th>
</tr>
</thead>
<tbody>
<tr>
<td>The conservation status of subtidal habitat.</td>
<td>This has been described and considered during the assessment.</td>
</tr>
<tr>
<td>Activities have been designed taking into account sensitive subtidal environmental aspects.</td>
<td>The assessment has identified impacts and if necessary would bring forward appropriate design and mitigation.</td>
</tr>
<tr>
<td>Where adverse effects are predicted, consider the extent to which the effects are temporary or reversible.</td>
<td>The duration of effects and recoverability have been considered.</td>
</tr>
<tr>
<td>Where offshore export cables are armoured and buried at a sufficient depth the effects of heat on sensitive species are unlikely to be a reason to refuse to grant consent.</td>
<td>Export cables are not included in the application; effects have been considered in the cumulative impact assessment.</td>
</tr>
<tr>
<td>Construction and decommissioning methods should minimise effects on subtidal habitats, taking into account other constraints. Mitigation measures may include avoidance of sensitive habitat; cable burial to allow seabed recovery; encouraging species colonisation on structures.</td>
<td>The sensitivity of species and potential for recovery has been considered in the assessment. Where necessary appropriate mitigation would be put forward.</td>
</tr>
<tr>
<td>Where cumulative effects are predicted as a result of multiple cable routes, it may be appropriate for applicants for various schemes to work together to ensure that disturbance is reasonably minimised.</td>
<td>Export cables are not included in the application; However, potential cumulative effects of cabling have been assessed along with the temporal scale for the installation of cables from other OWFs in the region. See e.g. paragraph 3.97.</td>
</tr>
</tbody>
</table>

3.22 In order to determine significance of any impacts, the magnitude of effect of the potential impacts has been assessed in relation to key marine areas as defined by other existing and emerging government policy. Thus, consideration has been given to the impacts of TKOWF within the context of the Greater Wash SEA area and the southern North Sea Marine Natural Area (MNA), the latter representing three of the recently proposed Marine Planning Areas2 (Defra, 2010) (Figure 3.2).

3.23 The presence of a candidate Special Area of Conservation - The Inner Dowsing, Race Bank and North Ridge cSAC – 4.54 km to the south of the TKOWF site, was also an important consideration in assessing the significance of some of the potential impacts set out in Table 3.4. Impacts on the benthic ecological interest features of the cSAC were assessed with regard to Regulation 35 of the Conservation of Habitats and Species Regulations 2010 and Regulation 18 of the Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 (as amended).

3.24 Further consideration has also been given to the impacts on features (species, habitats and broad habitats) listed for protection within the emerging network of Marine Conservation Zones (MCZs), to be created within UK waters under the Marine and Coastal Act 2009 (Net Gain, 2011).

Baseline environment

3.25 The results of the sediment analysis from the site-specific field surveys (Volume 3: Annex E; paragraphs 3.1 - 3.3) show that the substrate across the study area can be classified according to three broad sediment types (based on the simplified Folk classification): sublittoral coarse sediment (EUNIS3 code: SS.SCS), sublittoral sand (SS.SSA), and sublittoral mixed sediment (SS.SMX; see Figure 3.3). This corroborates previous findings from 2004, with the addition of small areas of circalittoral bedrock or boulders in amongst the three main substrates (EMU, 2005). In fact, sublittoral fine sand and coarse sand dominate the Greater Wash SEA area as a whole (Centrica Energy, 2007; Centrica Energy, 2009; JNCC, 2007; JNCC, 2008; Turnbull et al., 2005).

3.26 The seabed was classified as being typically tide-swept, with mobile sediments and sand scour across the area, with a net tidal flow that generally has a south easterly component in the eastern sector of the site and a south westerly component in the western sector of the site (see Volume 2: Chapter 2; paragraph 2.28). Naturally occurring levels of suspended sediments vary according to the tidal state, with spring tides showing the highest suspended sediment concentrations (SSC), peaking at 14-18 mg/l, against a normal range of 2-10 mg/l.

3.27 The qualifying features for the Inner Dowsing, Race Bank and North Ridge cSAC (Figure 3.4) are: ‘sandbanks which are slightly covered by the sea at all times’ and ‘reefs’ for Sabellaria spinulosa biogenic reefs (JNCC, 2010). These features are briefly described below as part of the study area description. More detailed information is included in Volume 3: Annex E; paragraphs 1.13 -1.18.

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2 East inshore, East offshore, and South East inshore Marine Planning Areas: the TKOWF lies within the East offshore MPA.

3 European Nature Information System - the pan-European system of coding habitats, species and sites in accordance with the NATURA 2000 framework.
Ecology within the wider study area

3.28 Table 3.8 provides a summary of the key benthic ecological features within the study area. These are comprised of five broad categories, which for brevity, are referred to as Habitats A-E. The biotopes have been grouped according to their general ecology and species richness and are based on biotopes of similar sensitivity and recoverability as defined by MarLin (www.marlin.ac.uk).

3.29 The predominant sediment type across the wider survey area was sublittoral coarse sediment with an area of sand and muddy sand in the shallower areas to the south of the TKOWF project area (Figure 3.3). The habitat present within the northern part of the development site generally reflected that of the northern and southern east parts of the wider study area, with predominantly species rich polychaete and bivalve communities present in the infauna - typical of Habitat A (biotope code4: SS.SCS.CS.MedLumVen (MedLumVen)) and abundant bryozoan and colonial ascidians present as epifauna (biotope code: CR.HCR.XFa.FluCoAs.SmAs (SmAs) (Figure 3.5)). In the far northern part of the study area the polychaete and bivalve communities become more impoverished – Habitat A with some influence of Habitat B evident (biotope codes: SS.SCS.ICS.MoVen, SS.SCS.CS.Pkef, SS.SCS.ICS.SSh and SS.SCS.CS.PomB, (MoeVen, Pkef, SSh and PomB respectively) with much lower species richness (Volume 3: Annex E; paragraph 3.19, Table 3.1).

3.30 To the northwest and west of the development site large areas of encrusting S. spinulosa with abundant infaunal polychaetes and bivalves were present - Habitat C (biotope code: SS.SBR.Por.SspiMx, (SspiMx)) (Volume 3: Annex E; paragraph 3.21). Whilst this biotope has some value in terms of the biodiverse benthic community it supports, none of the SspiMx surveyed was classified as Annex I reef. The SspiMx biotope has been widely recorded in the Greater Wash SEA region (Centrica Energy, 2007; Centrica Energy, 2009; Foster-Smith and White, 2001; Offshore Wind Power Ltd, 2002b; Sotheran et al., 2005). Shallow sandbank areas to the south of the study area (e.g. Dudgeon Shoal and North Ridge; see Figure 3.4 and Figure 3.5) typically supported impoverished polychaete communities dominated by Nephys cirrosa and Bathyporeia spp – Habitat D. (biotope code: SS.SSA.IFiSa.NcirBat (NcirBat)) (Volume 3: Annex E; paragraph 3.14).

Ecology within the TKOWF site

3.31 The main broad sediment type within the TKOWF site comprised sublittoral coarse sediment (Figure 3.3). In the northern TKOWF area the substrate was dominated by sandy gravel with scattered boulders, whilst in the southern part of the site large areas of sand and gravel with megaripples occurred (Figure 3.3) (Volume 3: Annex E; paragraph 3.2). The infaunal benthic community associated with the sandy gravel and boulders in the north was predominantly characterised by a species-rich community of polychaetes such as Mediomastus fragilis and Lumbrineris spp with ribbon worms (Nemertea spp.), venerid bivalves and amphipods also present - Habitat A (MedLumVen; Figure 3.5). Epifaunal communities in the northern TKOWF area were characterised by scour-tolerant, robust and fast-growing species able to colonise pebbles and unstable cobbles. These communities included dense colonies of the bryozoan Flustra foliacea, with other bryozoans and colonial ascidians also abundant - elements of Habitat A (SmAs; Figure 3.5) (Volume 3: Annex E; paragraph 3.10).

3.32 In the southern TKOWF area, the species composition was similar to MedLumVen but was generally dominated by bivalves instead of polychaetes. This biotope complex consisted of relatively impoverished polychaete communities (Pkef), and bivalve (e.g. Moerella spp.) and polychaete communities (MoeVen) – Habitat A/B (Volume 3: Annex E; paragraph 3.13). Epifaunal communities in the southern part of the TKOWF site were less diverse than those in the north and were dominated by species such as the tube worm Pomatoceros triqueter, barnacles Balanus spp. and bryozoan and coralline algae crusts – Habitat B (SmAs (Species Poor)). A small area of Mytilus edulis bed (biotope code: SS.SBR.Smuss.MytSS (MytSS)) occurred in the south of the TKOWF site, with other characterising epifauna including common starfish Asterias rubens, the bryozoan Flustra foliacea and the anemone Urticina felina – which is again similar to Habitat B (Volume 3: Annex E; paragraphs 3.20-3.24).

3.33 The SspiMx biotope occurred in discrete areas in both northern and southern areas of the TKOWF site – typical of Habitat C (Figure 3.5).

Features of conservation importance within the study area

3.34 Details of the features and sites of nature conservation interest are provided in Volume 2: Chapter 7. Details in this section focus on the benthos. As noted in paragraph 3.11, 49 locations were assessed for the potential presence of Annex I cobble, Mytilus or Sabellaria reef habitats (Figure 3.6). Though each of these areas met some of the assessment criteria, such as suitable substrate, characteristic species, and species diversity, only one small area of cobble reef to the northwest of the TKOWF site boundaries satisfied the criteria in full and could therefore be classified as Annex I geogenic reef habitat. This cobble reef was characterised by a species-poor assemblage of echinoderms and crustose communities – typical of Habitat E (biotope code: CR.MCR.EcCr, hereafter referred to as EcCr. Figure 3.6). The full assessment of each of the sampling locations for potential Annex I habitat has been presented in Volume 3: Annex E; Appendix 2b.

3.35 A number of the biotopes found within the study area also have potential conservation status as UK BAP habitats and/or OSPAR habitats (Table 3.7). Particular attention was given to the potential value of biotopes within the study area as habitat features of conservation importance (FOCI) and EUNIS broad habitats for which the network of marine protected areas within the North Sea MCZ will be designated.

3.36 Each of these habitat classifications have inter-relating features which overlap to different extents and also relate to statutory protected habitats. (Table 3.7) shows the relationship between biotopes and habitats of conservation importance. Their potential conservation value was assessed against the detailed description of the biotopes surveyed within TKOWF study area (Table 3.8).

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4 Biotope codes are defined and taken from Connor et al., 2004.

Triton Knoll Offshore Wind Farm Ltd

Environmental Statement
Figure 3.3 Sediment types within the TKOWF study area based on simplified Folk classifications
Figure 3.4 Conservation designations and Annex I habitats (data layer provided by NE/JNCC) within proximity to the TKOWF site
Figure 3.5 Benthic infauna and epifauna biotope map of the TKOWF study area
Figure 3.6 Assessment of potential Annex I reefs within the TKOWF study area
<table>
<thead>
<tr>
<th>Habitat description</th>
<th>Biotopes</th>
<th>EUNIS broad habitat (level 3)</th>
<th>Habitat FOCI</th>
<th>UK BAP</th>
<th>Annex I</th>
<th>OSPAR</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Mytilus edulis</em> beds on sublittoral sediment</td>
<td>SS.SBR.SMus.MytSS</td>
<td>Subtidal biogenic reefs (A5.6)</td>
<td>Blue mussel beds on sediment</td>
<td>Component of Annex I reef habitat</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td><em>Sabellaria spinulosa</em> on mixed substrata</td>
<td>SS.SBR.PoR.SspiMx</td>
<td>Subtidal biogenic reefs (A5.6)</td>
<td><em>Sabellaria spinulosa reef</em></td>
<td><em>Sabellaria spinulosa reef</em></td>
<td>Annex I reef</td>
<td><em>Sabellaria spinulosa reef</em></td>
</tr>
<tr>
<td>Echinoderms and crustose communities</td>
<td>CR.MCR.EcCr</td>
<td>Moderate energy <em>circalittoral rock</em> (A4.2)</td>
<td>n/a</td>
<td>n/a</td>
<td>Annex I reef</td>
<td>n/a</td>
</tr>
<tr>
<td>Brittlestar beds on sublittoral mixed muddy sediments</td>
<td>SS.Smx.CMx.OphMx</td>
<td>Sublittoral mixed sediments (A5.4)</td>
<td>n/a</td>
<td>Associated species: native oyster, fan mussel and timid burrowing anemone</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Infralittoral and circalittoral coarse sediment; infralittoral fine sand; circalittoral muddy sand.</td>
<td>SS.SCS.ICS⁵ SS.SCS.CCS⁵ SS.SSa.IFiSa⁶ SS.SSa.CMuSa⁶</td>
<td>Subtidal coarse sediment (A5.1) Sublittoral sand (A5.2)</td>
<td>Subtidal sands and gravels</td>
<td>May occur within: Sandbanks that are slightly covered by seawater all the time;</td>
<td>n/a</td>
<td></td>
</tr>
</tbody>
</table>

⁵ SS.SCS represents the broad habitat type Sublittoral sands and gravels (EUNIS code A5.1) only have one general trigger level.
⁶ SS.SSa represents the broad habitat type Sublittoral sand (EUNIS code A5.2).
Data limitations

3.37 In spite of the inevitable need to interpolate data collected from discrete sample locations and the artificiality of biotope classification (communities will generally show transition between one category and another), given the comprehensive body of data for the benthic fauna at the site and wider area the baseline characterisation study has provided a sufficient understanding of the distribution and sensitivity of the subtidal benthic habitats in and around the area to support a detailed and robust impact assessment process.

Summary of key ecological features

3.38 Table 3.8 provides a summary of the key benthic ecological features within the study area. The biotopes have been grouped into five broad community types according to their general ecology and species richness (habitats A-E) combining biotopes of similar sensitivity and recoverability based on MarLIN (www.marlin.ac.uk). This is to provide a more concise and coherent picture for Ecological Impact Assessment (EcIA). This is a logical approach for an environment where biotopes tend to grade into one another. In addition, it provides a better frame of reference for assessing conservation value. These simplified broad habitat types are listed in Table 3.8 and presented geographically in Figure 3.7.

3.39 The Inner Dowsing, Race Bank and North Ridge cSAC has been given specific and separate consideration in Table 3.8. Where appropriate proposed Marine Conservation Zones (MCZs) are also referred to.

Non significant issues

3.40 The desk study identified that heavy metal and polyaromatic hydrocarbons (PAHs) sediment contamination was unlikely at the TKOWF site, hence no sampling was undertaken and it is considered that there is no potential for impacts from this source (Volume 3: Annex E; Appendix 4 - paragraph 2.17).

3.41 The impact of noise and vibration was not considered to pose a significant threat to marine benthic invertebrate communities (as they do not have sound/pressure sensitive internal organs and do not generally rely on hearing, as do some fish) and this has therefore been scoped out of the impact assessment. The IPC scoping response accepted the scoping out of these issues (IPC, 2010). Inter-array cables will be buried in the seabed, and as a result the effect of heat arising from cables has not been further considered in this assessment.
Figure 3.7 Broad habitat types (combining biotopes of similar sensitivity and recoverability based on MarLIN (www.marlin.ac.uk))
Table 3.8 Summary of key ecological features within the study area and their conservation interest (see Figure 3.4 and Figure 3.7 for geographical representation)

<table>
<thead>
<tr>
<th>Description</th>
<th>Representative broad habitats/ biotopes</th>
<th>Protection status</th>
<th>Actual conservation interest</th>
<th>Distribution within study area</th>
<th>UK geographic distribution</th>
<th>Importance within study area and justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner Dowsing, Race Bank and North Ridge cSAC</td>
<td>sublittoral coarse sediment (SS.SCS/A5.1), sublittoral sand (SS.SSa/A5.2)</td>
<td>Annex I Habitats Directive</td>
<td>Annex I ‘sandbanks that are slightly covered by seawater all the time’ UK BAP habitat and MCZ-representative habitat.</td>
<td>Annex I sandbank features within the c SAC located 4.54 km south of the TKOWF site</td>
<td>Sandbanks are a UK-wide feature, with the largest area off the East Anglian coast; reefs are abundant throughout the British Isles.</td>
<td>International - European designated site.</td>
</tr>
<tr>
<td>A. Species-rich infaunal polychaete communities with ribbon worms, venerid bivalves and amphipods.</td>
<td>MedLumVen, Pkef, MoeVen, SmAs, OphMx SS.SCS/A5.1</td>
<td>None</td>
<td>Most widespread infaunal habitat throughout the TKOWF site and wider area.</td>
<td>Biotopes patchily distributed around UK waters coast. MedLumVen/ Pkef most extensive in Irish Sea, MoeVen mostly in SW England, W. Wales and off Kent coast.</td>
<td>Regional - although representative of a nationally important habitat, this is not a key geographic area but regionally important for MCZ.</td>
<td></td>
</tr>
<tr>
<td>B. Impoverished tube-building polychaete communities with abundant bivalves and hydroid and bryozoan epibiota.</td>
<td>PomB, MytSS, SmAs (Species Poor), SS.SCS.ICS SS.SCS.CCS</td>
<td>None</td>
<td>Most widespread epifaunal habitat throughout the area. MytSS occupies a few small areas, one of which is in the far south of the TKOWF site.</td>
<td>MytSS found patchily distributed around UK, PomB is mostly found on the west coast of the UK.</td>
<td>Regional - although representative of a nationally important habitat, this is not a key geographic area; but regionally important for MCZ.</td>
<td></td>
</tr>
<tr>
<td>C. S. spinulosa crusts with species-rich infaunal polychaetes and bivalves.</td>
<td>SspiMx</td>
<td>None</td>
<td>Potential to form Annex I reef area</td>
<td>Relatively large patches across the central and north western parts of the study area and falling within the southern TKOWF site.</td>
<td>S. spinulosa is widespread throughout the UK.</td>
<td>Local (but note the potential to become International if reefs form).</td>
</tr>
<tr>
<td>D. Impoverished communities, characterised by infaunal polychaetes and crustaceans and epifaunal crabs and starfish. Some areas lacking conspicuous fauna.</td>
<td>NcirBat, SS.SSa.IFiSa</td>
<td>Annex I Habitats Directive</td>
<td>NcirBat corresponds to areas of Annex I sandbank within cSAC; UK BAP habitat and MCZ-representative habitat.</td>
<td>Occurs to the south of the TKOWF site. Sandbank habitat is part of the wider system of sandbanks around The Wash and North Norfolk Coast.</td>
<td>Distribution is widespread down the west coast of England and mostly along the north half of the east coast of England.</td>
<td>Regional - although representative of Annex I sandbank the benthic communities are not internationally important.</td>
</tr>
<tr>
<td>E. Species-poor echinoderms and crustose communities</td>
<td>EcCr</td>
<td>Annex I Habitats Directive</td>
<td>Corresponds to Annex I cobble reef habitat</td>
<td>Restricted to a small site in the northwest of the study area</td>
<td>Reef habitat is widespread throughout the UK</td>
<td>International - due to protected status</td>
</tr>
</tbody>
</table>
Key parameters for assessment

3.42 This section sets out the Rochdale envelope parameters that describe the maximum adverse scenario in environmental terms for assessing the potential impacts on subtidal benthic habitats and species (Table 3.9), developed from the range of options, parameters and dimensions set out in the project description (see Volume 1: Chapter 6).

3.43 The assessment of the maximum adverse scenario for each receptor establishes the maximum potential adverse impact and as a result, TKOWFL is, therefore, confident that impacts of greater adverse significance would not arise should any other development scenario (as described in Volume 1: Chapter 6) to that assessed within this Chapter be taken forward in the final scheme design.

3.44 It is noted that only those design parameters detailed under each specific impact in Table 3.9 have the potential to influence the significance of the impact described. Therefore, if the design parameter is not discussed then it is considered not to have a material bearing on the outcome of the assessment.

3.45 The maximum adverse effects scenarios set out in Table 3.9 consider both direct and indirect impacts as well as inter-related effects from other potential changes to the environment (for example the effects from sediment plumes or changes to the hydrodynamic regime described previously in Chapter 2). Cumulative impacts scenarios are also described.

Table 3.9 Rochdale envelope scenarios assessed for potential impacts on subtidal benthic communities

<table>
<thead>
<tr>
<th>Potential effect</th>
<th>Maximum adverse scenario</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical disturbance to habitat and species and temporary habitat loss</td>
<td>Within the TKOWF site (Order Limits) during construction. Maximum construction footprint of 2.451 km² (1.8% of site) from:</td>
<td>The scenario described gives rise to the greatest area of seabed habitat disturbance during the installation process. Any of the other development scenarios or installation techniques considered within Volume 1: Chapter 6 would result in no greater or less of a disturbance footprint.</td>
</tr>
<tr>
<td></td>
<td>240 x 5 MW multi-bucket suction caisson and prepared ground; (1.21 km²);</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prepared area for eight substation jacket foundations and (0.101 km²);</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prepared area for four met mast gravity base foundations (0.008 km²);</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jack up barge seabed footprint for 240 turbines (~0.60 km²); and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation of up to 400 km of inter-array cables and 75 km of inter-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>array cables (trenching and anchor barge footprint (~0.53 km²). Decommissioning footprint of vessel seabed contacts all at new locations (jack up barge (~0.60 km²) and cable lay anchor barge (up to ~ 0.28 km²)): ~0.88 km²; ~0.6% of site).</td>
<td></td>
</tr>
<tr>
<td>Increased suspended sediment concentration (SSC), sediment deposition and scour</td>
<td>Disposal within the TKOWF (Order Limits) and during 5 years of construction of spoil material arising from:</td>
<td>The large concrete monopile option provides the greatest volume of spoil disposed of in situ (spoil from other options such as seabed preparation for gravity bases must be disposed of off-site at a licensed disposal site and as such are not considered). The drilling of concrete monopiles would also generate chalk spoil at some locations.</td>
</tr>
<tr>
<td></td>
<td>150 x 8 MW drilled concrete monopiles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation of up to 400 km of inter-array and 75 km of inter-substation cables</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation of drilled and piled met mast and substation foundations and placement of pipeline crossing infrastructure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum adverse scenario in environmental terms of an elevation in SSC and bed load as per spoil volumes and scenarios modelled (see Volume 2: Chapter 2).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Release of sediment into the water column. Localised scour of up to 23 m extent from an 10.5 m diameter concrete monopile foundation giving a scour footprint of 2,480 m². Release of up to circa 1100 m³ of scoured sediment per foundation (45 m diameter gravity base foundation).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The maximum length of cabling gives rise to the greatest potential for sediment disturbance and plumes. The spoil disposed of in situ or disturbed by cabling has been used to generate models and models to estimate sediment plumes and sediment deposition. Scour around the large concrete monopile (by virtue of its diameter) gives rise to the greatest scour extents (and scour footprint). Scour around the largest gravity base gives the greatest volume of scoured sediment released (both scenarios assume that no scour protection is placed to limit scour).</td>
<td></td>
</tr>
</tbody>
</table>

7 Scour protection would be placed within the prepared ground footprint and thus does not contribute to the total seabed loss area.
## Operation:

### Permanent seabed habitat loss

- Within the TKOWF site (Order Limits) and for the life of the project, the maximum loss of 0.88 km$^2$ seabed habitat (~0.6% of the TKOWF site) due to placement of:
  - 333 gravity base foundations with scour protection
  - 8 x substation jackets
  - 4 x met mast gravity base foundations
  - Pipeline crossing infrastructure

The scenario described gives rise to the greatest area of permanent seabed habitat loss. Any other development scenario or installation technique considered within Volume 1: Chapter 6 would result in no greater or less habitat loss.

### Change in hydrodynamics and inter-related effects on benthos

- Within the TKOWF site (Order Limits) and for the life of the project, using the maximum adverse scenarios set out in Volume 2, Chapter 2 (including foundation type, numbers and layout spacings, substations and met masts).

  Gives rise to a tidal current velocity reduced by, on average, 0.1 ms$^{-1}$ in the immediate vicinity of the turbine array, reducing by 0.2 ms$^{-1}$ depending on tidal state. Represents a change from weak/moderately strong to weak currents.

### Introduction of new habitat from colonisation of the foundation structures

- Within the TKOWF site (Order Limits) and for the operational life of the project, the introduction of new hard structures with a maximum surface area provided by:
  - 333 conical gravity base foundations and surface area of associated scour protection
  - 8 x substations with jacket structures
  - 4 x met masts on gravity base foundations
  - Pipeline crossing infrastructure
  - Rock armouring for exposed cables

The greatest number of gravity base structures for the turbines together with the greatest/number size of ancillary structures, and associated scour protection, provides the greatest surface area for colonisation both in terms of benthic recolonisation and/or introduction of alien species.

Any other development scenario considered within Volume 1: Chapter 6 would result in less area for colonisation.

## Decommissioning:

- Impacts are likely to include increases in suspended sediment concentrations and sediment deposition from the cutting or dredging works and temporary habitat disturbance from the removal of cables, pipeline crossing infrastructure and decommissioning vessel footprints e.g. jack-up barges. The impacts of these activities on subtidal benthic communities are considered to be similar to or less (for example, no disturbance if cables were to be left in situ) than those occurring as a result of construction. Occupation of the seabed habitat by structures will be reversed so that seabed areas become available for re-colonisation. Therefore, the impacts of decommissioning are, at worst, considered to be analogous to those described for the construction phase.

### Cumulative:

**Construction and operational phases – Habitat disturbance and loss**

- TKOWF scenario as described above for construction and operation habitat loss/disturbance effects.

**Construction phase – increases in suspended sediments and sediment deposition**

- TKOWF scenario as described above for construction sediment plumes and sediment deposition.

**Operational phase – changes to the hydrodynamic regime and inter-related effects on benthos**

- TKOWF scenario as described above for changes to hydrodynamic regime during the operational phase.

## Introduction of new habitat from colonisation of the foundation structures

- Within the TKOWF site (Order Limits) and for the operational life of the project, the introduction of new hard structures with a maximum surface area provided by:

  • 333 conical gravity base foundations and surface area of associated scour protection
  • 8 x substations with jacket structures
  • 4 x met masts on gravity base foundations
  • Pipeline crossing infrastructure
  • Rock armouring for exposed cables

The scenario described gives rise to the greatest area of permanent seabed habitat loss. Any other development scenario or installation technique considered within Volume 1: Chapter 6 would result in no greater or less habitat loss.

### Change in hydrodynamics and inter-related effects on benthos

- Within the TKOWF site (Order Limits) and for the life of the project, using the maximum adverse scenarios set out in Volume 2, Chapter 2 (including foundation type, numbers and layout spacings, substations and met masts).

  Gives rise to a tidal current velocity reduced by, on average, 0.1 ms$^{-1}$ in the immediate vicinity of the turbine array, reducing by 0.2 ms$^{-1}$ depending on tidal state. Represents a change from weak/moderately strong to weak currents.

### Introduction of new habitat from colonisation of the foundation structures

- Within the TKOWF site (Order Limits) and for the operational life of the project, the introduction of new hard structures with a maximum surface area provided by:

  • 333 conical gravity base foundations and surface area of associated scour protection
  • 8 x substations with jacket structures
  • 4 x met masts on gravity base foundations
  • Pipeline crossing infrastructure
  • Rock armouring for exposed cables

The greatest number of gravity base structures for the turbines together with the greatest/number size of ancillary structures, and associated scour protection, provides the greatest surface area for colonisation both in terms of benthic recolonisation and/or introduction of alien species.

Any other development scenario considered within Volume 1: Chapter 6 would result in less area for colonisation.

---

<table>
<thead>
<tr>
<th>Operation:</th>
<th>Decommissioning:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent seabed habitat loss</td>
<td>Impacts are likely to include increases in suspended sediment concentrations and sediment deposition from the cutting or dredging works and temporary habitat disturbance from the removal of cables, pipeline crossing infrastructure and decommissioning vessel footprints e.g. jack-up barges. The impacts of these activities on subtidal benthic communities are considered to be similar to or less (for example, no disturbance if cables were to be left in situ) than those occurring as a result of construction. Occupation of the seabed habitat by structures will be reversed so that seabed areas become available for re-colonisation. Therefore, the impacts of decommissioning are, at worst, considered to be analogous to those described for the construction phase.</td>
</tr>
<tr>
<td>Change in hydrodynamics and inter-related effects on benthos</td>
<td><strong>Cumulative:</strong></td>
</tr>
</tbody>
</table>
| Introduction of new habitat from colonisation of the foundation structures | **Construction and operational phases – Habitat disturbance and loss**

- TKOWF scenario as described above for construction and operation habitat loss/disturbance effects. |
| | **Construction phase – increases in suspended sediments and sediment deposition**

- TKOWF scenario as described above for construction sediment plumes and sediment deposition. |
| | **Operational phase – changes to the hydrodynamic regime and inter-related effects on benthos**

- TKOWF scenario as described above for changes to hydrodynamic regime during the operational phase. |

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Volume 2 – Chapter 3

3.18

RWE Npower Renewables Ltd
The TKOWF scenarios provide for the greatest surface area for colonisation by alien species and species that may have the same impact. Specific details and assumptions applied for the other activities are set out in Chapter 2 (physical processes).

### Operational phase – new habitat for colonisation

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>TKOWF scenario as described above for colonisation of structures by benthos and alien species. Cumulative effects with existing and planned R1 and R2 OWFs in the Greater Wash area and Hornsea Project 1.</td>
<td>The TKOWF scenarios provide for the greatest surface area for colonisation by alien species and species that may potentially influence biodiversity and productivity. As such this scenario also provides the maximum adverse case for the cumulative assessment of the same impact. Specific details and assumptions applied for the other activities are set out in the assessment text.</td>
</tr>
</tbody>
</table>

3.46 The project design envelope was established with a maximum number of turbines and associated foundations of ‘up to 333’ which has been used where appropriate as the basis for the ‘maximum adverse scenario’ in the impact assessment. Subsequently, and in response to the assessment of impacts on birds (see Volume 2: Chapter 6), the maximum turbine number has been reduced to ‘up to 288’ – the number set out in Schedule 1 of the draft DCO (application document reference 03/01). The basis of the assessment using the maximum of 333 turbines has been subsequently reviewed and an assessment based on the 288 turbine layout would be no greater than, and probably less than, the scenario assessed in the EIA, although if there were any beneficial effect on formation of new habitat on the structures, then with 288 turbines there would be marginally less surface area for such new habitat.

### Environmental assessment: construction and de-commissioning phases

#### Temporary habitat disturbance from construction plant and cable laying

3.47 Temporary habitat disturbance is likely to be restricted to the area of seabed prepared for foundation placement (turbines, substations and met masts) and the seabed areas disturbed by jack-up barge footprint, inter-array and inter-substation cable laying area and anchoring, predicted to be a maximum total area of 2.45 km² (1.8 % of the TKOWF site area). It should be noted that the prepared areas of seabed that are not subsequently covered by foundations, although able to recover, may have had coarser material placed on it as part of the seabed preparation process and as such its character would be changed, potentially influencing the type of benthic community that would colonise those areas.

3.48 All of the benthic biotopes have been assessed by MarLin as being either of moderate (Habitat C) or low (Habitat A, B, D and E) sensitivity to this kind of habitat disturbance due to their potential for rapid recovery following cessation of construction activities, despite a possible appreciable, immediate and localised decline in species richness as a result of disturbance. The assessment of recoverability is based in part on species mobility (and thus ability to repopulate from the immediate vicinity) as well as recruitment as a consequence of the high fecundity and reproductive strategies of the species within these biotopes (www.marlin.ac.uk). Reproductive traits that would benefit recovery include the short time to reach sexual maturity (e.g. two years for venerid bivalves and a few months for some species of bristleworm), large number of offspring and annual pelagic dispersal phase (Hill, 2007; Rayment, 2008).

3.49 Habitat C (SspiMx biotope) has been considered moderately sensitive, because of a tendency, in areas/patches where this species forms a stable and enduring crust, to lead to somewhat greater structural complexity and an associated increase in species diversity. Basic recovery of the benthos is likely to occur within one year (Holt et al., 1998) and re-establishment of associated communities within five to ten years (Newell et al., 1998).

3.50 The other habitats recorded across the TKOWF site are all considered to be of low sensitivity. For example, in habitat B, the MytSS biotope shows high recovery from habitat loss due to its high fecundity and planktonic larval stage. Recruitment is dependent on the physical processes in the area since larvae develop over a one month period in the plankton and therefore may be transported over a considerable distance (Anon, 2008). Indeed, *Mytilus edulis* may recover relatively quickly after construction due to its ability to rapidly colonise the turbine foundations as observed at the Horns Rev and Inner Dowsing wind farms (BioConsult, 2006; Offshore Wind Power Ltd, 2002b). Similarly, although there may be a loss of individuals in habitats A and D, there is unlikely to be a decrease in species richness and recoverability would be high. Habitat E (identified as Annex I cobble reef) will not be affected by temporary disturbance during construction as this lies outside of the TKOWF site and as such would not be disturbed by the turbine, substation or met mast foundation installation process nor by inter-array and inter-substation cable installation.

3.51 It is also important to consider the impact of habitat disturbance and temporary habitat loss from construction vessel activities. The operation of jack-up barges and use of vessel anchors is expected to cause localised abrasion and damage to benthic communities over an area of 0.8 km² in the short term and during the installation of each wind farm structure. While a full recovery of these habitats is anticipated as described above (paragraph 3.49 and 3.50), total recovery within the depressions left by the jack up barge spud legs is likely to occur over the medium term (~3 to 5 years) or potentially longer in the case of the SspiMx biotope in patches where *Sabellaria* crusts occur (5 to 10 years).

3.52 In summary, therefore, whilst there may be some very localised ecological effects in the short and medium term it is concluded that the benthic communities are of low sensitivity and recovery will occur. With the spatial extent of the impact being highly localised - *circa* 1.8 % of the TKOWF site (and much less in the wider Great Wash or Southern North Sea context) and occurring on widely distributed biotopes, the magnitude of effect is considered to be minor and of slight significance for benthic habitats and species. No long term significant impacts on the benthic features in the TKOWF site will therefore occur. A high level of confidence is ascribed to this assessment.

3.53 No impacts are predicted to occur to the integrity of the Inner Dowsing, Race Bank and North Ridge cSAC. This is based on the fact that there will be no construction-related seabed disturbance within the cSAC, the nearest boundary of which is approximately 5 km distant from the TKOWF site. Further details on the assessment of impacts to the
cSAC are presented in Volume 3: Annex D; section 6.1-6.2. Based on the results of the numerical modelling, a high level of confidence is ascribed to this assessment.

3.54 Effects arising from other design permutations will to lead to smaller areas of seabed habitat disturbance so that effects on benthic communities will be no greater and probably less than described and of no significance in each case.

**Increased suspended sediments, scour and sediment deposition**

3.55 The physical processes assessment describes background suspended sediment concentrations (SSC) in the order of 2-10 mg l⁻¹ with peaks of between 14-18 mg l⁻¹ during spring tides (Volume 2: Chapter 2, and Volume 3: Annex D; Figures 34 - 36). Cefas records from the southern North Sea indicate that ambient SSC values are generally in the range 8 to 32 mg l⁻¹ during winter and 4 to 16 mg l⁻¹ during summer (Volume 2: Chapter 2, and Volume 3: Annex D; Figure 37).

3.56 The maximum adverse scenario for sediment plumes suggests a short term elevation in SSCfrom turbine installation of 10-20 mg l⁻¹ above ambient within the area of turbine installation (within the array boundary), up to a maximum of 30 mg l⁻¹ where the tidal flow is aligned with on-going turbine installation work. Plumes are predicted to be of short duration, with limited extent, declining rapidly to non-detectable limits (4 mg l⁻¹ above ambient) within 5 to 10 km of the construction work.

3.57 The Inner Dowsing, Race Bank and North Ridge cSAC is approximately 4.5 km to the south of the TKOWF site boundary, so there is potential for some slight elevations in SSC within the cSAC. It should be noted that elevations of no more than 4 mg l⁻¹ across the wider cSAC are against a measured background level of around 30 mg l⁻¹ and for this reason, there are unlikely to be any significant effects (magnitude and significance of effect negligible) on the integrity of the cSAC. Based on the most sensitive Annex I habitat within the cSAC being *Sabellaria* reef, this site is considered to be of low sensitivity to SSC with very high recoverability (www.marlin.ac.uk).

3.58 The biotopes within the TKOWF site and wider study area are likely to be tolerant of increases in suspended sediment depending on the concentration and type of sediment and the period over which the increase occurs. Analysis of soil profiles across the study area revealed that sediments that may be disturbed by the drilling of large concrete monopile foundations contained between 33-85 % cohesive silt/clay particles (Volume 3: Annex D, section 5.2.1.2). Tidal movement in the area would disperse SSC rapidly with concentrations dropping quickly such that over the 60 day period of modelling (which included continuous, sequential turbine installation) the levels drop away significantly. Indeed, for soil profile 1, after 55 days the concentrations are less than 4 mg l⁻¹ (Volume 2: Chapter 2, from paragraph 5.47).

3.59 Inter-array and inter-substation cable installation (using jetting techniques) is predicted to have a very localised and short term effect on SSC, with increases of on average 10 mg l⁻¹ but not exceeding 20 mg l⁻¹ within the immediate vicinity of cabling and lasting no more than 10 days (Volume 2: Chapter 2, paragraphs 2.54-2.55).

3.60 An increase in SSC (and sedimentation) would have different effects depending on the nature of the species affected. Deposit feeders, including many polychaetes, are likely to favour an increase in sedimentation as this can often lead to introduction of organic materials from a greater proportion of fine sediments in the substrate. *S. spinulosa* may also benefit as this species depends on the presence of suspended sediment (sand) for tube growth and therefore some increases could facilitate growth.

3.61 Sediment deposition has the potential to affect other suspension feeders, such as shallow burrowing venerid bivalves that occur throughout much of the area (Habitats A, B and C), unless the animal is able to clear the sediment.

3.62 However, the physical processes study predicted that whilst some deposition of fine sediments occurs (0.4 mm thick within 5 km and 1.2 mm within 1 km of the release locations), these are likely to be re-suspended within 30-60 minutes by the tide (Volume 3: Annex D, section 5.2.1.2). Coarser sediments deposited in the immediate vicinity of cable installation are predicted to be only 0.375 mm thick.

3.63 The most vulnerable group of animals is likely to be sessile epifauna, such as hydroids and bryozoans, as these may be affected by sediment deposition from increased levels of SSC. These occur most frequently in Habitat E, representative of cobble reefs, however, sediment deposition drops significantly outside the TKOWF site and therefore SSC levels are unlikely to significantly affect this habitat.

3.64 Whilst these changes could lead to a shift in community structure from suspension feeders to deposit feeders, the MarLIN benchmark is given as a persistent increase in SSC (e.g. of 100 mg l⁻¹) over 1 month before mortality would occur (Tyler-Walters et al., 2001). The modelled outputs for the TKOWF assessment show that SSC drop rapidly from the maximum (average 20 mg l⁻¹ above ambient) over a period of 2-3 months with different levels of persistence depending on the soil profile (Figures 46-49; Volume 3: Annex D, section 5.2.1.2). Since these concentration levels are only marginally elevated compared to the 100 mg l⁻¹ benchmark given above, and given the natural fluctuations in the area that the resident species tolerate, it is unlikely that any major shifts in community structure would occur over this period and where habitats are affected, high recoverability is predicted. To put this into perspective, studies have shown the bivalve *M. edulis* to be tolerant of sediment levels at 440 mg l⁻¹ over 25 days (Purchon, 1937 in Tyler-Walters, 2008).

3.65 Given that the predicted increases in SSC and subsequent sedimentation are relatively localised, limited in concentration, intermittent and temporary and the prevailing benthic communities are tolerant of a naturally occurring sediment load, it is considered that the magnitude and significance of effect will be negligible. The confidence in this assessment is high.

3.66 The physical processes assessment (Volume 2: Chapter 2) has also examined the potential for scour as a result of the presence of wind farm structures and the implications for secondary, far-field scour effects. The study concluded that the maximum adverse scenario for scour of sand and finer sediments would be in the surficial sediment layer of circa 1 m depth and up to circa 23 m radius from the foundation (based on a large concrete monopile foundation; Table 2.13), giving rise to a scour footprint of 2,480 m² per turbine foundation (equating, for an array of 150 such foundations, to a scour footprint of 0.37 km²). However, the remaining coarser gravel fraction would not be scoured away and would tend to prevent further erosion. The near-field effects are considered to be of minor significance given the limited area affected. Estimated maximum volumes of material that might be released by scour were circa 1100 m³ derived from the largest gravity base foundations. This material would be dispersed away in the same way that material released during construction is predicted to be dispersed. The horizontal extent of scour does not reach far beyond the individual foundations and therefore the interaction of scour pits from multiple foundations will not occur given the minimum spacing set out in Volume 1: Chapter 6. Given that scour effects are predicted to be localised only, effects on benthic habitats will be negligible.
3.67 Far-field effects were predicted to give rise to very slight reductions in tidal regime and flow speed. However, these far-field effects were considered to be negligible and were not of a magnitude sufficient to give rise to any significant change in sediment scour or mobility.

3.68 In summary, increased sediment from construction activities, resulting in elevated SSC, scour and sediment deposition represent short term and temporary effects over relatively localised extents and affecting habitats and species that have a low sensitivity to such effects; as such they are considered to result in negligible impacts on the benthic communities in and around the TKOWF area.

3.69 Effects arising from other design permutations (for example other foundation designs or installation techniques) will tend to lead to smaller increases in SSC (and resulting sediment deposition) or less scour, so that effects on benthic communities will be no greater and probably less than described and of no significance in each case.

Release of contaminants from accidental spills

3.70 During construction, contamination of sediments may potentially result from accidental spillage of substances such as grout, oils and fuels. However, given that published guidelines will be followed and best working practice will be adopted, and incorporated within an Environmental Management Plan (EMP), including planning for accidental spills from construction activities, there is unlikely to be an issue. Any minor leachate will be dispersed quickly through tidal action to concentrations below possible effects levels. Consequently it has been concluded that there will be negligible impact from accidental release of contaminants. A high level of confidence is ascribed to this assessment.

Environmental assessment: operational phase

Habitat loss due to the presence of foundations and scour protection

3.71 Long term habitat loss will occur directly under all foundation structures and scour protection. The maximum total area of habitat loss is estimated as circa 0.88 km$^2$, equating to circa 0.60 % of the site seabed.

3.72 The small proportion of seabed take over the TKOWF site with regard to each biotope type (Table 3.10) (negligible magnitude) and the wide distribution of these habitats throughout the Greater Wash SEA area (negligible sensitivity), means that the maximum area of habitat loss will be negligible in terms of the structure and functioning of the benthic ecosystem. A high level of confidence is ascribed to this assessment.

3.73 There will be no direct effects within the cSAC, the permanent loss being limited to the area within the TKOWF boundaries) and as a result no impact on the cSAC habitats can occur.

<table>
<thead>
<tr>
<th>Ecological feature</th>
<th>Representative biotopes</th>
<th>Biotope area in TKOWF site (km$^2$)</th>
<th>Biotope area lost (km$^2$) (based on indicative layout)</th>
<th>% habitat loss in TKOWF area (based on indicative layout)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat A</td>
<td>MedLumVen, Pkef, MoeVen, SmAs, OphMx</td>
<td>120.17</td>
<td>0.70</td>
<td>0.58</td>
</tr>
<tr>
<td>Habitat B</td>
<td>PomB, MytSS, SmAs (Species Poor), ICS</td>
<td>5.65</td>
<td>0.04</td>
<td>0.71</td>
</tr>
<tr>
<td>Habitat C</td>
<td>SspIMx</td>
<td>9.13</td>
<td>0.05</td>
<td>0.60</td>
</tr>
</tbody>
</table>

3.74 Effects arising from design permutations other than the maximum adverse scenario (for example other foundation designs or installation techniques) will tend to lead to less permanent habitat loss so that effects on benthic communities will be no greater and probably less than described and of no significance in each case. The assessment is also considered insensitive to the final location of the wind farm structures given the common nature of the biotopes affected.

Changes in hydrodynamic regime

3.75 Benthic communities are primarily characterised by the sediment type and water movement. Benthic communities within the TKOWF study area are characteristic of areas with relatively high rates of water flow, therefore may be vulnerable to reductions in water flow if the decrease is sufficient to reduce the availability of suspended food particles, and consequently inhibit feeding and growth.

3.76 The presence of the foundation and turbine structures will introduce changes to the local hydrodynamic and wave regime (see Volume 2: Chapter 2, from paragraph 2.56) which in turn could lead to inter-related effects on the benthos. The results of the hydrodynamic modelling indicates that the presence of the wind farm would result in near-field current effects (within the wind farm footprint), with only very slight changes in far-field tidal currents. The baseline currents, on average, range between 0.43 ms$^{-1}$ to 0.57 ms$^{-1}$ peaking at 1.2 ms$^{-1}$ during spring tides. Thus, the tidal strength can be classified as weak to moderately strong. Within the TKOWF site, slight changes in currents would range between -0.1 to +0.07 ms$^{-1}$ (depending on the location and tidal state) but for the majority of time there would be a slight reduction in current speed (with a maximum decrease of 0.1 ms$^{-1}$) (Tables 10 and 11, Volume 3: Annex D). Far-field, the changes have been modelled as an average increase in current strength of 0.05 ms$^{-1}$. Based on the predicted range of near-field and far-field values, the tidal strength would still range between weak to moderately strong. The direction of currents would be broadly maintained thereby preserving the general pattern of circulation. Given the small magnitude of change to the hydrodynamic regime no significant effects are expected on

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8 MNCR definition of tidal strength (McLeod, 1996): Moderately strong (0.5 – 1.5 ms$^{-1}$); Weak (<0.5 ms$^{-1}$); Very Weak (negligible).
the benthic invertebrate communities within or adjacent to the TKOWF as a result of localised changes to tidal currents.

### 3.77 Effects arising from other design permutations

Effects arising from other design permutations, for example other foundation designs or installation techniques, will tend to lead to reduced effects on tidal currents so that effects on benthic communities will be no greater and probably less than described and of no significance in each case.

### Introduction of new habitat from the foundation structures

**3.78** Turbine, substation and met mast foundations and pipeline crossing infrastructure will represent a suitable substrate for colonisation of species that may otherwise not occur within the area. While this may cause an overall increase in biodiversity and/or productivity, this represents a change in the pre-construction benthic communities that would naturally occur in the area. Whether this effect is viewed as ‘positive’ or ‘beneficial’ can be subjective. For example, an increase in abundance of a commercially important invertebrate resulting from new habitat may provide benefits to commercial fisheries, although from an ecological perspective this may be perceived as a slight negative impact. Negative effects may also occur if alien species become established.

**3.79** Where a hard structure is introduced to an area of soft sediment, there will be an increased surface area for colonisation, thereby creating a new habitat type. Such ‘artificial reef’ structures have been suggested as having potential to enhance local populations of species such as lobster in the Greater Wash SEA (Linley, et al. 2007). This in turn can have benefits further up the food chain as the benthic organisms colonising the structures provide an additional food source for local fish and shellfish species. Studies at the Horns Rev wind farm in Denmark have provided evidence that offshore wind farm structures are used as successful nursery habitats for the edible crab *Cancer pagurus* (BioConsult, 2006). However, any benefits are only likely to occur on a very localised basis, i.e. to habitats in close proximity to the foundation structures. This includes habitats A, B and C only (see Figure 3.7).

**3.80** Given the presence of other hard substrata (including boulders, wrecks and offshore structures) in the area, it is likely that colonisation by a range of common species including bryozoans, ascidians and molluscs such as mussels (see paragraphs 3.31 and 3.49) would occur. Whilst it is likely that colonisation will take place, the extent to which this results in measurable increases in the local population and whether any commercially or ecologically important species would benefit is unknown and therefore, the beneficial effects are assessed as being of negligible significance and a low level of confidence is ascribed to this assessment.

**3.81** In terms of potential negative impacts, there is the potential for colonisation and establishment of populations of alien species such as the Pacific marine midge *Telmatogoton japonicus* and the Japanese skeleton shrimp *Caprella mutica* to occur on new structures. Whilst not currently listed as an alien species in the UK (NNSS, 2010), marked increases in a monoculture population of *T. japonicus* has been noted from ongoing monitoring studies of the Danish Horns Rev offshore wind farm in the North Sea (Bioconsult, 2006). In addition, it appears that the increasing number of offshore wind farms may provide one of the means by which these species might expand its geographic range (Brodin and Andersson, 2007). *C. mutica* has been found colonising the foundations of the Horns Rev wind farm, and adjacent seabed habitat (Bioconsult, 2006).

**3.82** There is generally very little information concerning the intolerance of different benthic biotopes to invasion by alien species. Changes are most likely to occur if an alien species is able to out-compete the native species for food or space. The monitoring study of Horns Rev (where *C. mutica* and *T. japonicus* were present) did not demonstrate a negative impact of alien species on the benthic communities despite their ability to rapidly colonise the turbine structures. Since the Greater Wash area, and the area surrounding the Triton Knoll site, has boulder and gravel substrates that naturally provide potential ‘hard’ structures for colonisation by species, including those not naturally occurring, it is unlikely that turbine foundations and scour protection will contribute to any great extent to the spread of alien species, should they occur here. Given the results of monitoring at Horns Rev described above, it is not certain that such colonisation if it were to occur, would necessarily impact ecological integrity. It is therefore concluded that any potential impacts are likely to be negligible in magnitude and significance. With the existence of other suitable hard substrata in the area available for colonisation by alien species, the sub-sea structures of the TKOWF would not alone influence the spread of alien species into new areas. However, a low level of confidence is ascribed to this assessment.

### Environmental assessment: cumulative effects

**3.83** Effects arising from other design permutations (other than the maximum applied), for example other foundation designs, will tend to lead to a lesser amount of new substrate available for colonisation thereby leading to affects that are no greater and probably less than described both in the case of increased biodiversity (whether perceived as positive or negative) and as a basis for the introduction or spread of alien species. The assessment is also considered insensitive to the final location of the wind farm structures given that each structure would be colonised equally regardless of its precise location.

### Activities resulting in subtidal habitat loss/ disturbance

**3.84** A number of projects and activities within the Greater Wash SEA area may contribute to cumulative impacts during the construction, operation and decommissioning phases of the TKOWF. Relevant activities in relation to the potential effects on the benthos are considered to include other offshore wind farms, the TKOWF export cables, and marine aggregate dredging activities. These potential impacts are discussed below.

**3.85** The baseline data collected for other projects, including wind farm assessments in the Greater Wash SEA area, suggests that the benthic communities present at TKOWF are broadly representative of the benthic ecology in the wider region. Impact assessments from these wind farms predicted that the maximum adverse scenario for habitat loss within the foundation footprint is also minor and typically less than 1% of the development area, with a further area subject to temporary disturbance during construction. It is estimated that the total loss of habitat from the Rounds 1 and 2 OWF in the Greater Wash SEA area is 4.68 km² amounting to 0.03% of the Greater Wash SEA area. In the case of cabling, the maximum export and inter-array cable lengths for all of the Greater Wash OWF projects are calculated to be to circa 1,300 km and 1,100 km respectively (including the Triton Knoll inter-array and export cables). Assuming a 0.5 m wide area of disturbance, the installation of all of the subsea cables would lead to the

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9 Based on an estimate of the foundations for each OWF area accounting for 1% of the development area.
temporary disturbance of circa 0.65 km² of seabed habitat. Similarly small areas may be affected in each case by the activity of jack up vessels or anchoring activity.

3.86 In addition, Hornsea Project 1 lies some distance to the north-east of TKOWF. Information available at the time of writing suggests that this project could comprise up to 332 turbines using gravity base foundations of up to 40 m diameter. An estimated footprint for this project of 0.42 km² is therefore assumed as a maximum adverse scenario. The Hornsea Project 1 is expected to have up to 4 HVDC export cables each thought to be circa 100 km in length, 400 km in total. This would give rise (assuming a 0.5 m wide area of disturbance), to a seabed footprint of circa 0.2 km². Similarly small areas are assumed to be affected in each case by the placement of substation or met mast structures and the activity of jack up vessels or anchoring activity. Data presented in the Hornsea scoping report suggests a similar seabed sedimentary environment to that covering much of the Greater Wash suggesting the similar broad-scale biotopes consistent with the rest of the broader offshore region.

3.87 In relation to other activities, aggregate dredging in the Humber region covers a licensed area of to 469 km² but recent figures suggest that only circa 24 km² of that has been subject to dredging in the last reported year of 2010 (The Crown Estate, 2011), amounting to circa 0.14 % of the SEA area (although this in fact includes some dredging that lies outside of the Greater Wash SEA area).

3.88 The habitats highlighted as being most sensitive in the Greater Wash region were *Sabellaria* dominated communities and cobble reefs, although mitigation on a project by project basis (where required) through micro-siting of turbines will tend to lead to a reduction and/or avoidance in the impact on the most sensitive habitats including Annex I reef habitat.

3.89 The significance of the cumulative effect of habitat disturbance is negligible for all habitats given the small area affected, the widespread nature of the biotopes affected and capacity for rapid recovery (see paragraphs 3.47 to 3.54).

3.90 Again the most sensitive habitat is likely to be *Sabellaria* crusts as recovery would take longer (minimum of one year; see 3.49). The baseline assessments of other wind farms in the area indicate that *Sabellaria* in non-reef form is widespread throughout the Greater Wash SEA area. Therefore, even with the cumulative area of *Sabellaria*-dominated habitats lost or disturbed, the effects are considered likely to be minor or negligible in comparison to the distribution within the wider Greater Wash SEA area (refer to Volume 3: Annex E; paragraph 4.4).

3.91 No cumulative impacts will occur on *Sabellaria* Annex I reef habitat as none were identified within the footprint of the TKOWF development. However, it should be reiterated that the Greater Wash SEA is the most important area for *Sabellaria* reef in the North Sea MCZ (NetGain, 2011) and therefore mitigation would be essential for those projects where reef was identified to avoid areas of reef prior to commencement of offshore construction works.

3.92 In relation to the Inner Dowsing, Race Bank and North Ridge cSAC, several offshore wind farms and aggregate licence areas lie within the site boundary and therefore there may be an effect of habitat loss/disturbance on this site, but the TKOWF project will not contribute directly to that cumulative effect since it lies outside the cSAC and can not itself give rise to such direct effects. The same is true of the MCZ areas proposed in this region, none of which overlap directly with the TKOWF site.

3.93 In summary, given the small areas of commonly distributed biotopes that will be subject to disturbance together with the high potential for recovery, no significant cumulative effects are predicted. A high to moderate level of confidence is ascribed to this assessment.

3.94 Effects arising from other design permutations (other than the maximum applied for all OWFs), for example other foundation designs or installation techniques, or shorter cables, will tend to lead to less habitat loss or disturbance thereby leading to effects that are no greater and probably less than described. The assessment is also considered insensitive to the final location of the wind farm structures given that the prevailing biotopes are commonly and widely distributed.

**Construction activity resulting in elevated SSC and sedimentation**

3.95 Cumulative sedimentation may arise from projects within one tidal excursion of the TKOWF. The coastal processes study (Chapter 2) therefore looked at the potential for cumulative effects from sediment transport arising from dredging licence Area 440, adjacent to the southern TKOWF site boundary, and concluded that suspended sediment levels from the dredging are unlikely to be detectable at more than 500 m from the dredging vessel with concentrations of 4 mg/l in the immediate vicinity of the dredger assuming the largest possible overspill rate (refer to paragraph 2.134). Consequently, there may only be a cumulative elevation in SSC in the southern part of the TKOWF site which could cause additional stress on benthic habitats. The biotopes within 500 m of Area 440 include: SspMx , MoeVen/SSh mosaic , NcIrBat and MytSS. However, the concentration levels would not be much greater than those from the installation of turbines and would only occur over a short time scale (2-3 months) and therefore cumulative effects would be localised and minor.

3.96 There is also unlikely to be significant interaction between plume(s) arising from aggregate dredging activities and the likely plume from any jetting along the inter-array cable routes. This is due to the small sediment concentration (with increases of on average 10 mg/l but not exceeding 20 mg/l), short duration (up to 10 days) and limited spatial extent of elevated SSCs during cable installation, even based on the maximum adverse scenario of using jetting techniques.

3.97 The installation of the Triton Knoll export cables will similarly generate slight increases in SSC; installation of the export cables at the offshore extents might combine with the plumes generated by construction activities conducted within the TKOWF site, but the increases in SSC will be at low concentrations and localised so no significant cumulative impacts on benthic habitats and species are anticipated.

3.98 In summary, given the intermittent and temporary nature of the sedimentation arising from dredging, the relatively localised dispersion and limited interaction of the plumes and the low sensitivity of the benthic communities to increases in SSC, the magnitude of effect is considered to be negligible to minor, with the significance of effects considered to be slight. A high level of confidence is ascribed to this assessment.

3.99 Effects arising from other design permutations (for example other foundation designs or installation techniques) will tend to lead to smaller increases in SSC thereby leading to effects that are no greater and probably less than described. The assessment is also considered insensitive to the final location of the wind farm structures given that the prevailing biotopes are commonly and widely distributed.
Changes in hydrodynamic regime during operation

3.100 The largest potential for cumulative effects would arise in the area between the TKOWF and Race Bank OWF arrays where the largest cumulative changes to the hydrodynamic regime are predicted. The greatest changes are predicted at mid ebb on spring tides where an increase in current speed of 0.05-0.1 ms\(^{-1}\) above baseline levels may occur, although this small increase would be very short-lived, over just the tidal cycle (Chapter 2; paragraph 2.115). More widely, the cumulative effect of the offshore wind farms in the Greater Wash SEA area would be a reduction in the high water spring tide current speeds by up to 0.05 ms\(^{-1}\) adjacent to the north Norfolk coastline and a small increase in flow speed along the Lincolnshire coast at high water.

3.101 The cumulative effect of multiple arrays is marginally greater than the effect of the TKOWF array alone, where the spatial extent of the effects is generally confined to the areas between the separate OWF developments. Consequently the cumulative effect of hydrodynamic change on the benthic ecology is considered unlikely to be greater than the effect within the TKOWF site. For most biotopes this effect ranges between negligible to minor magnitude and of negligible/slight significance. A high level of confidence is ascribed to this assessment.

3.102 The hydrodynamic assessment has also considered cumulative effects on tidal currents arising from the deepening of the seabed by dredging activity in the adjacent Area 440 (see Chapter 2, paragraphs 2.138 – 2.143). The assessment concludes that cumulative effects from the dredging activity contribute that any changes to tidal flows will be largely restricted to the boundaries of the dredge area so that significant cumulative effects through an interaction with the TKOWF are not anticipated. That being the case no significant effects on the wider benthic habitats will occur.

3.103 Effects arising from other design permutations (for example other foundation designs) will tend to lead to smaller changes in the hydrodynamic regime thereby leading to effects that are no greater and probably less than described. The assessment is also considered insensitive to the final location of the wind farm structures given that the prevailing biotopes are commonly and widely distributed.

Introduction of new habitat from the foundation structures

3.104 Even with all the OWF taken into consideration, the extent to which the new habitats represented by the subsea structures result in increases in the local biodiversity or productivity is uncertain. Therefore the effects are assessed as being localised and of negligible magnitude and therefore are not considered to be significant. Given the uncertainties in the scope of any benefits a low confidence is ascribed to this assessment.

3.105 The collective offshore wind farms also have the potential to form habitats for alien species, the introduction of which may have impacts on native benthic communities. Cumulatively, the Greater Wash OWFs, including TKOWF, could increase the theoretical possibility of the spread of such alien species. Using evidence from the risk assessment of the amphipod *Caprella mutica*, a possible effect may include a decline in species richness due to competition and a decline in abundance of polychaetes (prey item) due to the high consumption rates of *Caprella* (UK Non-Native Organism Risk Assessment Scheme). However, as discussed previously in relation to TKOWF, there is likely to be a negligible effect on benthic features given the localised nature of the habitats created by the wind farms and the apparent lack of any evidence of adverse effects on native communities collected at existing offshore wind farms. However given the uncertainties, a low level of confidence is ascribed to this assessment.

3.106 Effects arising from other design permutations (for example other foundation designs) would tend to lead to reduced levels of recolonisation and potential of alien species as they would represent a smaller area of new habitat. The assessment is considered insensitive to the final location of the wind farm structures given that the colonisation will occur through planktonic or other waterborne vectors and as such is not specific to a given location.

Mitigation and monitoring

3.107 Given the lack of likely significant effects on the benthic communities within or adjacent to the TKOWF area, including within the cSAC and proposed MCZ sites, and having considered direct, indirect, inter-related and cumulative effects, it is considered that no specific mitigation is required in relation to the general benthic assemblages that currently exist across the TKOWF area. However, in recognition of the importance of the Greater Wash area for Annex I habitats (particularly Sabellaria) a pre-construction survey of those parts of the TKOWF area likely to be directly affected by the construction works will be undertaken such that any Annex I habitat recorded can be avoided by the appropriate micro-siting of wind farm structures. Where such Annex I habitats are recorded during the pre-construction survey, a post construction survey will be undertaken to act as a check on the condition of those habitats following the completion of the construction works.

3.108 No significant uncertainties have been encountered in conducting these assessments. The conclusions on likely effects are based on an extensive knowledge base describing the likely response and recovery of the benthos to the disturbance caused by the construction of offshore wind farms or by analogous anthropogenic activity. As such it is considered that no specific monitoring of the general benthic assemblages is required (noting the proposed provisions in relation to potential Annex I habitat). However, a check on the recovery of the seabed sedimentary habitats to construction disturbance will be provided by the physical monitoring of the seabed within the TKOWF area using swath bathymetry and side scan sonar surveys and as previously described in Chapter 2.

Summary

3.109 The combined results of the desktop literature review and the site specific surveys, presented in the benthic ecology characterisation studies, concluded that the benthic communities are generally typical for the southern North Sea region and the Greater Wash SEA area.

3.110 The potential impacts associated with the wind farm construction and operation were found to be of negligible to slight significance given the generally localised nature of the effects, the common, widespread and insensitive nature of the prevailing benthic communities and the absence of Annex 1 habitats within or proximate to the TKOWF site boundary.

3.111 The TKOWF alongside the other offshore wind farms and aggregate extraction sites in the Greater Wash SEA will not give rise to significant cumulative effects on benthic
3.112 Effects arising from other design permutations (for example other foundation designs) have been considered and it has been concluded that for all potential impacts, these permutations will tend to lead to the same or smaller level of effect.

Transboundary statement

3.113 Transboundary impacts have been considered with respect to benthic ecology. Since the predicted effects will be restricted to within or in relatively close proximity to the TKOWF study area and will affect commonly found biotopes, and given that TKOWF lies at least 130 km from the nearest EEZ of another member state, no trans-boundary impacts are expected to occur.

Conclusions

3.114 The potential impacts of the TKOWF both in isolation and when considered cumulatively will not give rise to any significant impacts on subtidal benthic communities. In each case, potential impacts have been adjudged to be localised and only affecting commonly distributed benthic communities. Furthermore, many of the potential effects are temporary with the benthos showing a high potential for recovery. Permanent effects are limited to habitat loss arising from the placement of structures and associated scour protection; these are judged to be limited in extent.

3.115 Impacts on the adjacent Inner Dowsing, Race Bank, and North Ridge cSAC have been assessed as being of no significance. Impacts here are limited to indirect effects arising from sediment plumes from the construction activities acting either in isolation or cumulatively with the dredging activities at Area 440. Similarly, no direct effects will occur on proposed MCZ sites. Indirect effects would be limited to potential short term impacts from sediment plumes during the construction phase but this will not lead to any long term significant effects on the habitats of interest in these areas.

3.116 Most impacts were assessed with a high level of confidence, although uncertainties associated with the colonisation of the wind farm structures by native or alien species are acknowledged and the assessment of these effects is of correspondingly lower confidence.

References


FEPAs Strategic Review of Offshore Wind Farm Monitoring Data Associated with FEPA Licence Conditions: Annex I Benthic Ecology. ME1117. v1.2


