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12 MARINE AND INTERTIDAL ECOLOGY

12.1 Introduction

12.1.1 This Chapter of the Environmental Statement (ES) describes the benthic (marine and intertidal) biological resource within the proposed Galloper Wind Farm (GWF) site as well as the wider area of the Outer Thames Estuary and southern North Sea.

12.1.2 This Chapter serves to characterise the distribution and abundance of benthic species known to occur within both the study area and across the wider region as established through site specific or regional surveys. Subsequent to this, the Chapter then presents the findings of the assessment of potential impacts of the construction, operation and decommissioning phases of the GWF project and provides detail on the approach to mitigation of these impacts.

12.1.3 This Chapter covers effects on the habitats below mean high water springs (MHWS). Effects on terrestrial habitats above MHWS are presented in Chapter 23 Terrestrial Ecology. Impacts on the fisheries resource are described separately in Chapter 13 Fish and Shellfish Resource.

12.1.4 For the purposes of the Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009, Figure 12.3 and 12.7 to 12.9 taken together with this Chapter, fulfil the requirements of Regulation 5(2)(l) in relation to the effects of the proposed development on marine and intertidal ecology.

12.2 Guidance and Consultation

Legislation, policy and guidance

12.2.1 The following paragraphs provide detail from the National Policy Statement (NPS) for Renewable Energy Infrastructure (EN-3) (July 2011), which contains specific requirements for assessment of impacts on the subtidal and intertidal zones.

12.2.2 The specific assessment requirements for marine and intertidal ecology, as detailed within the NPSs, are repeated in the following paragraphs. Where any part of the NPS has not been followed within this assessment, it is stated within in the ES why the requirement was not deemed relevant or has been met in another manner.

12.2.3 In relation to the intertidal, Section 2.6.81 of NPS EN-3 (Department for Energy and Climate Change (DECC), 2011) details that where necessary an assessment of the effects of installing cable across the intertidal zone should include information about:

- Potential loss of habitat (Section 12.6);
12.2.4 Section 2.6.113 of NPS EN-3 identifies the key considerations with regard to the subtidal environment and states that where relevant the assessment should include:

- Loss of habitat due to foundation type including associated seabed preparation, predicted scour, scour protection and altered sedimentary processes (Section 12.6 and 12.7);
- Environmental appraisal of intra-array, inter and intra-array and export cable routes and installation methods (Section 12.6);
- Habitat disturbance from construction vessels’ extendible legs and anchors (Section 12.6);
- Increased suspended sediment loads during construction (Section 12.6); and
- Predicted rates at which the subtidal zone might recover from temporary effects (Section 12.6).

12.2.5 In addition, this assessment has been undertaken with due consideration of the following legislation and guidance (and amendments, where appropriate):

- Draft guidelines for data acquisition to support marine environmental assessments for offshore renewable energy projects (Centre for Environment Fisheries and Aquaculture Science (Cefas), 2011);
- Guidance on the Assessment of Effects on the Environment and Cultural Heritage from Marine Renewable Developments (draft). Produced by: the Marine Management Organisation (MMO), the Joint Nature Conservation Committee (JNCC), Natural England, Countryside Council for Wales (CCW) and Cefas, December 2010; and

Consultation

12.2.6 The following paragraphs and Table 12.1 provide a summary of the consultation with regard to marine ecology that has taken place at key junctures throughout the planning phase of the project. Furthermore, an
indication of where the relevant consultee’s concern has been addressed within this Chapter is also provided.

12.2.7 Galloper Wind Farm Limited (GWFL) undertook early consultation with the JNCC, Natural England, the Marine and Fisheries Agency (MFA) (now the MMO) and Cefas on the requirement for, and scope of, site specific surveys to characterise the benthic environment. Furthermore, representatives of Cefas and JNCC were invited to be present during the data interpretation phase of the site surveys to ensure the work was carried out in accordance with the Scope of Works.

12.2.8 Subsequent consultation on the predicted impacts on the marine and intertidal ecology and approach to their assessment took place through the formal request for a Scoping Opinion from the Infrastructure Planning Commission (IPC) and the pre-application consultation required under the Planning Act 2008 (through the submission of the Preliminary Environmental Report (PER)).

Table 12.1 Summary of consultation on marine and intertidal ecology issues

<table>
<thead>
<tr>
<th>Date</th>
<th>Consultee</th>
<th>Summary of comment</th>
<th>Section where addressed</th>
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</thead>
<tbody>
<tr>
<td>July and August</td>
<td>JNCC/Natural England/ MFA/Cefas</td>
<td>Confirmed requirement for and scope of benthic survey</td>
<td>Section 12.4</td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
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<tr>
<td>Aug 2010</td>
<td>JNCC/Natural England (Scoping Opinion)</td>
<td>In recognition of presence of <em>Sabellaria spinulosa</em>, Annex I surveys will be required prior to construction</td>
<td>Section 12.4</td>
</tr>
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<td></td>
<td></td>
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<tr>
<td>Aug 2010</td>
<td>JNCC/Natural England (Scoping Opinion)</td>
<td>Discussion of potential alteration of habitat due to compaction of sediment</td>
<td>Section 12.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 2011</td>
<td>MMO (Section 42)</td>
<td>Pre-construction surveys will be required to identify newly established reefs</td>
<td>Section 12.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td>July 2011</td>
<td>JNCC/Natural England (Section 42)</td>
<td>Geophysical survey information is recommended to estimate the extent of any <em>Sabellaria spinulosa</em> identified</td>
<td>Section 12.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Details of the pre-construction <em>S. spinulosa</em> survey, including</td>
<td>Section 12.11</td>
</tr>
<tr>
<td>Date</td>
<td>Consultee</td>
<td>Summary of comment</td>
<td>Section where addressed</td>
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<tr>
<td></td>
<td></td>
<td>timings of survey work in relation to construction works and accommodation of micrositing should be included</td>
<td>Section 12.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide more detail pertaining to presence of <em>Sabellaria spinulosa</em> including inconsistencies between the grab samples and drop down camera samples</td>
<td>Section 12.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide further clarity of the estimated loss of seabed associated with this development</td>
<td>Section 12.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>State the quantities of sediment to be deposited within the array</td>
<td>Section 12.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modelling of the dispersion of material from the GBS foundation installation would be a useful tool to display the potential effects of this material</td>
<td>Section 12.6</td>
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<tr>
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<td></td>
<td>Assess the potential effects of the predicted volumes of sediment released as a result of scour</td>
<td>Section 12.6</td>
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<tr>
<td></td>
<td></td>
<td>Include the potential for re-powering</td>
<td>Re-powering is not assessed within the ES. See Chapter 5 for details.</td>
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<tr>
<td></td>
<td></td>
<td>Use the results of the sediment modelling to inform the cumulative impact assessment</td>
<td>Section 12.10</td>
</tr>
</tbody>
</table>

**12.3 Methodology**

**Study area**
12.3.1 The study area, with regard to marine and intertidal ecology, encompassed the GWF site, export cable corridor and surrounding seabed within a single tidal excursion (i.e. the net horizontal extent of one tidal cycle) (Figure 12.1). The intertidal study area extended from mean low water springs (MLWS) to MHWS, for approximately 500m either side of the proposed landfall at Sizewell (adjacent to Sizewell Hall to the south, and the end of Sizewell Gap road to the north) (Figure 12.2).

Characterisation of existing environment

12.3.2 There are an extensive number of existing studies that cover the area, which enable a detailed broadscale characterisation of the benthic resource within the wider study area. A number of these studies encompass the GWF study area and therefore augment the level of site specific knowledge. Those existing studies that are considered of relevance to the GWF project include:

- Environmental Statement’s (ES’s) from other offshore wind farm developments within the Outer Thames Strategic Area (GE Wind Energy, 2002; Greater Gabbard Offshore Winds Limited (GGOWL), 2005; Global Renewable Energy Partners (GREP), 2002; London Array Ltd (LAL), 2005);

- A broadscale survey conducted by Cefas as part of national monitoring programmes (Cefas, 1997);

- Investigative surveys\(^1\) by the conservation agencies (JNCC and Natural England) as part of the Natura 2000 site selection process; and

- The Outer Thames Estuary Regional Environmental Characterisation (Marine Aggregate Levy Sustainability Fund (MALSF), 2009).

12.3.3 These data were used to provide background for the area and support for site specific surveys conducted specifically for the GWF Environmental Impact Assessment (EIA).

12.3.4 A number of site specific surveys were undertaken for the study area associated with the GWF site and the export cable corridor. The methodologies for these surveys are summarised in the following paragraphs with technical survey reports provided in the following appendices:

- CMACS benthic survey report: Technical Appendix 12.A (CMACS, 2010);

- OSIRIS geophysical survey report Technical Appendix 9.B (OSIRIS, 2010a and OSIRIS 2010b); and


\(^1\) http://www.naturalengland.org.uk/ourwork/marine/sacconsultation/default.aspx
12.3.5 The survey methodologies were agreed with the relevant agencies (Cefas, JNCC and Natural England).

12.3.6 No dedicated intertidal survey was undertaken as the area of landfall and surrounding environs have been surveyed in detail as part of the Greater Gabbard Offshore Wind Farm (GGOWF) consent studies and the results are considered to remain valid. The habitats of the intertidal are predominantly barren shingle and ephemeral seaweeds (see 12.4.4) and are not considered sensitive or likely to have changed since the characterisation surveys of 2005. This approach was clearly set out in the Scoping Report (SSER and RWE NRL, 2010) and received no objection from the consultees.

GWFL’s survey strategy

12.3.7 The surveys were carried out in accordance with a Scope of Works which was agreed in consultation with the JNCC, Natural England and the Cefas. The work comprised the use of a combination of benthic grab, drop-down camera and epibenthic beam trawl sampling in order to fully characterise the benthic infaunal and epifaunal communities (full details of which are provided in Technical Appendix 12.A).

12.3.8 The grab and camera drop sampling locations were based around a pre-determined grid that was informed by the knowledge gained from existing studies that covered the GWF study area (namely GGOWL, 2005 and MALSF, 2009). The survey was designed to generate even coverage of the seabed across the study area (see Technical Appendix 12.A).

12.3.9 In addition to sample stations within the development footprint, near field comparison sampling stations were positioned outside the development area and control (reference) stations were located outside a tidal excursion south of the area and out of the path of tidal flow to the east (offshore). In total 97 grab stations and 98 drop down camera stations were selected for sampling (see Figure 12.1).

12.3.10 After the approximate location of each sample station was chosen, these locations were fine-tuned, as necessary, to ensure representative sampling of different habitats based on interpretation of the side scan sonar and multibeam data collected as part of the geophysical survey programme (Chapter 9 Physical Environment and Technical Appendix 9.B).

12.3.11 The beam trawl surveys undertaken as part of the CMACS benthic surveys were carried out along sample lines perpendicular to the export cable corridor and were positioned to sample all of the benthic biotopes identified in the GGOWF EIA (GGOWL, 2005) in the adjacent cable corridor (see Figure 12.1). Additional reference trawls were located to the north and south of the cable route (see Figure 12.1). The surveys were carried out by CMACS Ltd, supported by Aquatech Ltd and Osiris Projects Ltd survey vessels in the autumn of 2009 from 19th September to 28th October and in the spring of 2010 from 1st March to 14th March.
12.3.12 In addition to the CMACS benthic surveys, pre construction beam trawl surveys were carried out by Brown and May in autumn / winter 2008 (Brown and May Marine Ltd, 2009a) and spring 2009 (Brown and May Marine Ltd, 2009b) in order to characterise the fisheries resource of GWF. The results of these surveys are described in full in Chapter 13, but the epifaunal communities recorded are also described here.

Subtidal benthic grab survey

12.3.13 A total of 97 stations were selected for taking single grab samples for benthic invertebrate infauna and sediment analyses (Figure 12.1). A mini Hamon grab (0.1m² sample area) was used to sample the seabed; this was an equivalent design to that used in the original GGOWF EIA, which therefore ensured continuity between the two projects and enabled comparison of the datasets. Samples were rejected if they were of less than 5 litres (i.e. less than 40% of the grab’s total capacity), or 2.5 litres over hard-packed sands. Stations were only abandoned after three successive failures to obtain a sample. Grab samples were successfully obtained from 90 of the stations. Any stations that were abandoned were added to the stations to be visited with the drop down camera.

12.3.14 The drop-down camera system utilised a freshwater housing unit, which permitted images to be obtained in low visibility/high turbidity environments. Still images were obtained at all 98 camera stations and at the seven failed grab stations. In addition, images were taken at four grab stations where there was considered to be potential for the presence of the Ross worm Sabellaria spinulosa based on the interpretation of the geophysical survey data (see Figure 9.1) or knowledge from the previous studies associated with the GGOWF project. S. spinulosa when occurring in reef form, serves as an important and sensitive habitat (as discussed in detail in Section 12.4). Consequently, the survey strategy was carefully adapted in accordance with guidance (e.g. Gubbay, 2007) and through consultations with the statutory nature conservation bodies to ensure that the appropriate techniques were utilised to ensure adequate characterisation with minimal damage to the feature.

12.3.15 At stations where S. spinulosa aggregations were recorded, further photographs were taken between 20m and 40m north, south, east and west of the original location. If the species was observed in those images, a further four images were taken between 70m and 100m north, south, east and west of the original location. The aim was to estimate the spatial extent of aggregations when present.

Subtidal epibenthic survey

12.3.16 Four epibenthic surveys have been undertaken to characterise the existing environment; in autumn (October 2008) and spring (April 2009) (as part of
wider surveys to characterise the fish and shellfish resource, see Chapter 13), and by CMACS in the autumn of 2009 and spring of 2010 as part of the benthic sampling campaign to ensure full coverage of the export cable corridor was achieved.

12.3.17 All surveys were carried out using a standard Cefas-design 2m beam trawl with a 5mm square mesh cod-end insert and chain matrix between the beam and foot-rope. Trawling was undertaken for a period of 5 to 10 minutes over a distance of approximately 300m into the prevailing current with a speed of approximately 2 knots over the ground, in accordance with guidelines (Boyd, 2002).

12.3.18 A digital photograph was taken of each trawl sample before any sorting or identification took place. Epibenthic invertebrates were counted and identified to species level where possible, with colonies of hydroids, soft corals and bryozoans being recorded as present or absent or recorded by weight. Any invertebrates not identified in the field were retained and preserved for future taxonomic identification. The samples collected during the trawls undertaken by Brown and May in 2008 and 2009, were subsampled at sea for two of the trawls due to the large number of organisms caught (Brown and May Marine Ltd, 2009b).

**Analysis of benthic and epibenthic data**

12.3.19 The macrofauna was identified to species level wherever possible and counted. Biomass of infauna was estimated by major taxonomic group by blotted wet weight. For quality control purposes, the use of low power microscopes were available during sorting, and a proportion of the samples (minimum 10%, typically one sample randomly selected from each batch of ten recently sorted samples) was re-sorted by an experienced sorter other than the original. Under this protocol, if the number of animals found in the original sorting was less than 95% of the total found (sorting plus re-sorting) all of the other samples in the appropriate batch sorted by that person were re-sorted (see Technical Appendix 12.A for full details).

12.3.20 Univariate analyses were conducted to characterise the benthos, although multivariate analysis was not included for this characterisation survey. The univariate analysis included determining the abundance of taxa recorded in the samples, the species richness, and undertaking diversity analysis using the Shannon Wiener diversity index. In addition, the communities present were classified, where possible, in accordance with the Marine Habitat Classification for Britain and Ireland (version 04.05) (Connor et al., 2004).
**Intertidal surveys**

12.3.21 Given the extent of existing data on the intertidal area at Sizewell, available through GGOWF intertidal studies, no new dedicated intertidal survey was undertaken for GWF. Therefore, as the results are considered to remain valid, the CMACS report for GGOWF (CMACS, 2005a) was used to inform the baseline for the proposed GWF. A number of GWF specific Phase 1 habitat surveys have been undertaken in the area of the cable landfall however these did not include the intertidal area and are therefore not considered in this chapter.

12.3.22 The coverage of the survey area in relation to the GWF project study area is provided in Figure 12.2. The intertidal survey was undertaken on 6th May 2005 at low tide. Intertidal biotopes were mapped by a walk-over survey supported by hand searching of intertidal sediments using a trowel. Biotopes were described according to Connor *et al.* (2004).
Assessment of impacts

12.3.23 Impacts associated with the construction, operation and decommissioning of GWF are assessed in accordance with the methodology detailed in Chapter 4 Approach to EIA. The details provided in Chapter 5 Project Details have been used to establish a realistic worst case development scenario for the assessment of impact on marine and intertidal communities (see Table 12.3).

12.3.24 The impact assessment has been informed by a number of dedicated studies, such as the numerical modelling undertaken to establish potential effects on the hydrodynamic and therefore, geomorphological regime (Chapter 9). The assessment of impacts presented within this ES have also been informed by studies associated with existing wind farms. Of particular relevance are the ongoing monitoring studies at the adjacent GGOWF project (GGOWL, 2005).

12.3.25 Other Chapters within this ES (such as Chapter 10 Marine Sediment and Water Quality) have been used to inform the assessment where inter-relationships are relevant.

12.4 Existing Environment

Intertidal ecology

12.4.1 There are a number of designated sites to the north and south of the cable landfall which include these features, as detailed in Chapter 8 Nature Conservation Designations. Sizewell Beach is managed by Suffolk Wildlife Trust, although the study area has no statutory designation. The beach is backed by sand dunes and supports vegetated shingle habitat, which is a UK Biodiversity Action Plan (UKBAP) habitat and is rare and decreasing in Britain and Europe (GGOWL, 2005). Although these habitats were included within the intertidal survey, they are present above MHWS are therefore considered as terrestrial so are assessed within Chapter 23.

12.4.2 The beach at Sizewell consists of an area of upper shore steep shingle backed by open dune habitat with a shallower gradient lower shore of sand with some overlying shingle. Landward of the beach lies a dynamic shingle ridge vegetated by patches of forbs and occasional clumps of marram grass (see Chapter 23, Section 24.4 for further detail). Sea kale Crambe maritima occurs abundantly in this landward zone right up to the high tide mark. There are also occasional small accumulations of decomposing fucoid seaweeds and dead wood along the strandline (CMACS, 2005a).

12.4.3 Below the MHWS the beach is a narrow stretch of shingle and sand approximately 40m wide (The Ecology Consultancy, 2010, Royal Haskoning, 2009) (Figure 12.3). In terms of biotopes, the 2005 CMACS intertidal survey (see Table 12.2) identified barren littoral shingle (LS.LCS.Sh.BarSh) and barren littoral coarse sand (LS.Lsa.MoSa.BarSa) as the dominant communities of the upper and lower shore respectively within the survey area on Sizewell Beach. The only other intertidal biotope noted in the survey was
ephemeral green or red seaweed (freshwater or sand influenced) (LR.FLR.Eph) which was present on five large concrete anchor blocks (Target Note 1 on Figure 12.3). In small areas of the upper shore shingle there were patches of barren sand 5 to 10m² in extent. These were classed as barren littoral coarse sand (Target Note 1 and 2 on Figure 12.3). No macrofaunal life was noted in any intertidal biotope, and no biotopes or species of any sensitivity / value were identified.

12.4.4 Although the detailed survey was completed in 2005, it is unlikely that the intertidal communities identified would have changed significantly in the intervening years. The community composition is determined by the shingle substrate which creates few opportunities for colonisation leading to depauperate numbers of individuals and species. The methodology for the intertidal assessment was outlined in the GWF Scoping Report, and no concerns were raised by the Statutory Nature Conservation Agencies (SNCA).
Subtidal ecology

Infauna and epifauna – regional context

12.4.5 The benthic habitats of the southern North Sea are defined by the substrata of the seabed (Jones *et al*., 2004). Mobile sand dominated habitats are generally considered to be species poor and are characterised by robust species such as annelid worms and fast burrowing bivalves (Barne *et al*., 1998, Jones *et al*., 2004). Epibenthic flora and fauna normally occur on mixed substrata with significant coarse components, where a range of micro-habitats allow colonisation by a wide array of species (Jones *et al*., 2004).

12.4.6 The GGOWF ES (GGOWL, 2005) summarised the work done to that date on the regional context of the offshore communities. Key studies used in the GGOWL (2005) assessment included Glemarec (1973), Kunitzer *et al*., Frauenheim *et al*., together with site specific studies for other offshore wind farms Gunfleet Sands, Kentish Flats and London Array (GREP, 2002, GE Wind Energy, 2002, LAL 2005). These studies conclude that the offshore communities found in the Outer Thames Estuary region are very much dependent on the substrate with species composition varying from finer to coarse sediments. The MALSF Regional Environmental Classification (REC) work (MALSF, 2009) found four broad groups of benthic infauna across the region, dominated at the high level by sublittoral coarse sediment (SS.SCS) and sublittoral sands and muddy sand (SS.SSa) habitat complexes (Connor *et al*., 2004).

12.4.7 Surveys for GGOWF identified the five most abundant taxa at the Greater Gabbard site, and areas immediately adjacent, as the Ross worm *Sabellaria spinulosa*, the barnacle *Verruca stroemia*, the porcelain crab *Pisidia longicornis*, the sea urchin *Echinocyamus pusillus* and the polychete worm *Lumbrineris gracilis* (GGOWL, 2005). These species are patchily distributed throughout the site.

12.4.8 The five main biotopes / communities recorded were as follows:

- **SS.SSA.IiSa.imoSa** Infralittoral mobile clean sand with sparse fauna;
- **SS.SCS.ICS.Glap** *Glycera lapidum* in impoverished infralittoral mobile gravel and sand;
- **SS.SCS.CCS.MedLumVen** *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel;
- **SS.SBR.PoR.SspiMx** *Sabellaria spinulosa* on stable circalittoral mixed sediment; and
- **Scalibregma** (annelid worm) dominated sands / muddy sands.

12.4.9 A common denominator of all of the biotopes / communities in the study area is that they are all adapted to surviving in turbid waters with very high levels of suspended sediments (GGOWL, 2005).
12.4.10 The MALSF REC project identified two broad infaunal groups which were present across the GWF study area: Cluster B and Cluster C. Cluster B is associated with coarse mixed muddy, sandy gravels and gravelly sands. Species richness and diversity, together with biomass, were high in comparison to other sample clusters across the REC area (MALSF, 2009). Conspicuous species included the polychaetes, *S. spinulosa*, *Lumbrineris gracilis*, *Notomastus* spp., the amphipod *Ampelisca spinipes*, brittlestars Ophiuroidea and sea anemones Actiniaria. Biotopes associated with this cluster were; SS.SCS.CCS.MedLumVen, SS.SMu.ISaMu.AmpPlon, SS.SCS.CCS, CR.MCR.SfR and SS.SBR.PoR.SspiMx (MALSF, 2009).

12.4.11 Cluster C was associated with comparatively clean sand and slightly gravelly sand sediments (MALSF, 2009). The associated macrofauna within each grab sample were sparse in comparison with the other faunal groupings and were characterised by a range of typical sand and gravelly sand species such as the polychaetes *Nephtys cirrosa*, *Ophelia borealis* and *Glycera oxycephala*, the amphipods *Bathyporeia elegans* and *Urothoe brevicornis*, the mysid shrimp *Gastrosaccus spinifer* and Ophiuroidea (MALSF, 2009). Biotopes associated with this cluster were SS.SSa.IFiSa.MoSa and SS.SSa.IFiSa.NcirBat (MALSF, 2009).

12.4.12 Dense aggregations of the *S. spinulosa* have been found in the deeper, polychaete dominated areas, on mixed sediments across the GWF study area (MALSF, 2009). *S. spinulosa* is a common species which often forms “crusts”, which in many cases are temporary features that break up in autumn / winter storms (Gubbay, 2007 and Limpenny et al, 2010). The species can also occur in reef form, at which point it is considered of high ecological importance, further discussion on this is provided in Paragraphs 12.4.53-69.

12.4.13 Interpretation of sidescan surveys to summarise major seabed features for GGOWF (GGOWL 2005) found no indications of extensive reef like structures, and suggested most of the area away from the Gabbard and Galloper sandbanks to be generally thin layers of sand and gravel over clay. The ES for GGOWF therefore concluded that given the evidence it was unlikely that there were areas of substantial *S. spinulosa* communities within the site although it could not be ruled out. However, it should be noted that the sidescan did not extend all the way to the south-east corner of the proposed GWF development area.

12.4.14 The only *Sabellaria* reefs found by the MALSF REC surveys were well to the south of GGOWF and GWF in the vicinity of Long Sand Head approximately 20km to the south of the GWF boundary (MALSF, 2009).
Results of GWF surveys

Infauna

Univariate analysis of infauna

12.4.15 The infaunal analysis of the GWF survey was based on 90 Hamon grab samples of 0.1m² each. From the samples analysed, a total of 6,052 individuals from 265 taxa were identified, the majority to genus or species level but some only identifiable to higher taxonomic levels (e.g. to phylum) (CMACS, 2010). The greatest numbers of taxa in any one sample was 63 at Station G78 to the north-west of the Galloper Bank, between the existing GGOWF inter array cable route and the proposed GWF inter array cable route (Figure 12.4). Figures 12.4 to 12.6 (see Pages 20, 21, and 22) indicate the number of species, abundance and diversity of the benthic samples both in the wind farm area and along the export cable corridor. Plots 12.1 and 12.2 show, as a percentage, the numbers of taxa and the number of individuals within the major groups present in the infauna. The samples from GWF were similar in composition of taxa to those collected at GGOWF.

Plot 12.1 Numbers of taxa of the major groups present in infauna across the GWF site

![Pie chart showing the distribution of taxa in the infauna across the GWF site]

Source: CMACS (2010)

12.4.16 The greatest number of individuals found in a grab sample was 476 at Station G51 to the east of Area B (Figure 12.4). Samples from deeper water areas generally had more individuals than shallower sites, although not all deep water samples contained high numbers of invertebrates. Similarly, although not always the case, coarser sediments seemed to support higher numbers of invertebrates compared with finer sediments (especially well...
illustrated along the export cable route and when comparing the western and eastern sections of Area A).

12.4.17 There were markedly fewer individuals to the east of the Inner Gabbard Bank and on the inter- and intra-array and export cable routes. The exception to this trend was Station G51 (on the south-eastern edge of Area B), although this location was dominated by a large number of a single species (S. spinulosa).

Plot 12.2 Numbers of individuals by major groups present in infauna across the GWF site

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annelida</td>
<td>59%</td>
</tr>
<tr>
<td>Crustacea</td>
<td>11%</td>
</tr>
<tr>
<td>Mollusca</td>
<td>12%</td>
</tr>
<tr>
<td>Echinodermata</td>
<td>8%</td>
</tr>
<tr>
<td>Cnidaria</td>
<td>2%</td>
</tr>
<tr>
<td>Others</td>
<td>8%</td>
</tr>
</tbody>
</table>

Source: CMACS (2010)

12.4.18 The dominant faunal group across the survey site was annelid worms, which comprised just under half of the total number of taxa, and just over half of the total number of individuals recorded (Plots 12.1 and 12.2, see above). Crustaceans and molluscs were the next most commonly recorded groups, both in terms of taxa and individuals.

12.4.19 Only a very limited number of the faunal samples were not dominated by annelids and this accords with the results of sampling at both the GGOWF and London Array wind farms (CMACS, 2005a, 2005b, see Technical Appendix 12.A).

12.4.20 As would be expected, given the previously described predominance of annelid taxa, the most abundant species across the survey site were also annelids, with six of the 12 most abundant species belonging to the group. The most common species from the samples was the keelworm Pomatoceros triqueter with a total of 807 individuals recorded across the proposed GWF site. This species is sessile, occupying a calcified tube which encrusts the surface of gravels, and shells. This species was well distributed
across the survey area, being found at a total of 37 stations, but was particularly abundant at stations G51 and CG12.

12.4.21 The Shannon Wiener diversity index\(^2\) is displayed for each sample station in Figure 12.6. The most diverse areas were towards the southern end of the export cable corridor, the north-eastern and central parts of Area A and the western part of Area B. Areas of markedly lower diversity were at the northern end of the export cable corridor, the north-western corner of Area A, and the north-eastern part of Area B (see Technical Appendix 12.A).

12.4.22 There was a clear divide across the site with regard to invertebrate diversity. At each station; to the east of the Galloper Bank and in the inter and intra-array and export cable route areas there were relatively few taxa per station, whereas more taxa were recorded to the west of the Galloper Bank and across Area A (see Technical Appendix 12.A).

\(^2\) A standard analysis used to calculate species diversity in a community. Diversity indices provide more information about community composition than simply species richness (i.e. the number of species present); they also take the relative abundances of different species into account.
**Biotopes**

12.4.23 The infaunal assemblages within the study area have been classified using the standard marine biotope classification (Connor *et al.*, 2004). Biotopes are based on both faunal communities and sediment and other physical characteristics of the environment, although the faunal communities tend to be the overriding factors. Where no matching biotope is possible, a description of the community and sediment characteristics has been given.

12.4.24 Infaunal data and sediment information from the grab surveys was the primary source of information but epifaunal data from the beam trawl surveys and descriptions of the seabed from the geophysical surveys were also taken into account, particularly in mapping the likely extend of biotopes.

12.4.25 The overall approach to community analysis was based on the use of multivariate analysis. The multivariate analysis results have not been included within this baseline as in depth analysis of the site is not required at the characterisation stage, but will be undertaken during any pre-construction surveys. **Figure 12.7** provides an overview of the biotopes found within the GWF study area (CMACS, 2010) and a comparison of how they relate to those recorded for the GGOWF project in 2005.

12.4.26 The biotopes found within the GWF site include:

- SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel;
- SS.SMX.OMx.PoVen, Polychaete-rich deep *Venus* community in offshore mixed sediments;
- SS.SSa.IFiSa.NcirBat, *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand; and
- SS.SCS.CCS.PomB, *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles.

12.4.27 The majority of the GWF site has a good fit with SS.SCS.CCS.MedLumVen and SS.SMX.OMx.PoVen which collectively represent the ‘deep Venus community’ (**Figure 12.7**). This classification was made on the basis of the regular occurrence of species of the polychaete genera *Lumbrineris* and *Notomastus* and the small burrowing echinoid *Echinocyamus pusillus* in addition to the bivalve diversity from the grab samples as a whole (Connor *et al.*, 2004). On a regional scale, SS.SCS.CCS.MedLumVen was the principal biotope at the GGOWF site with a similar dominance of *Lumbrineris gracilis* and *Echinocyamus pusillus* to the present study (CMACS, 2005a). This biotope was also widespread on the London Array site (CMACS, 2005b) to the south of the GWF and GGOWF. It is interesting to note that the SS.SSa.IFiSa.ImoSa biotope (infralittoral mobile sand) biotope that was predominant following EIA surveys for GGOWF in 2005 was not identified after this survey at the adjacent site. Biotopes are both spatially and temporally variable (Connor *et al.*, 2004) and to some extent the temporal
gap between the surveys is important; however, there are differences in depth with more shallow, sandy areas on the Inner Gabbard and Galloper banks (GGOWF) amongst a deeper coarse sediment seabed while the GWF area is predominantly a coarse sediment seabed. Nevertheless, SS.SCS.CCS.MedLumVen dominates the seabed on both wind farm areas as previously described.

12.4.28 Within the eastern edge of the GWF site boundary, a sandy biotope was recorded with a polychaete and amphipod fauna SS.SSA.IFiSa.NcirBat ‘Nephtys cirrosa and Bathyporeia’ spp. in infralittoral sand’. Biotopes such as these are typical of the southern North Sea and the east coast of England with NcirBat recorded at the London Array OWF site (CMACS, 2005b) and Scroby Sands (Worsfold & Dyer, 2005) with a high abundance of Nephtys spp. and Bathyporeia spp. at the Gunfleet OWF site (Titan, 2002, RPS, 2008) and Scroby Sands (Worsfold & Dyer, 2005).

12.4.29 Within the GWF site boundary there were also three discrete patches of the coarse sediment with SS.SCS.CCS.PomB. This biotope contained sparse infauna but with large numbers of the encrusting polychaete Pomatoceros triqueter and the barnacle Verruca stroemia with epifaunal organisms such as sea urchins and brittlestars, leading to a classification of SS.SCS.CCS.PomB ‘. This biotope is typical of tide-swept conditions where the seabed is unstable; it has not been recorded in other wind farm benthic surveys in the southern North Sea but the principal species used for the classification, Pomatoceros triqueter, was common in samples from the Inner Gabbard and London Array (CMACS 2005a, 2005b) and Verruca stroemia was abundant in the samples from the Inner Gabbard (CMACS 2005a).

12.4.30 Along the cable corridor three biotopes were recorded:

- SS.SCS.CCS.PomB;
- SS.SCS.CCS.MedLumVen; and
- SS.SSa.IMuSa.SsubNhom, Spisula subtruncata and Nephtys hombergi in shallow muddy sand.

12.4.31 The inshore portion of the export cable corridor was characterised by a sandy biotope; which had a fauna of polychaetes and bivalves and was classified as SS.SSA.IMuSa.SsubNhom. Offshore the majority of the cable route was dominated by SS.SCS.CCS.PomB with a central portion of SS.SCS.CCS.MedLumVen.

12.4.32 A comparison of biotope plots of the adjoining cable routes between GGOWF and GWF shows a strong degree of similarity (CMACS, 2010). The surveys for the GGOWF cable route in 2005 recorded predominately infralittoral mobile clean sand with sparse fauna comprising two subgroups of the SS.SSa.IFiSa.IMoS biotope. The difference in faunal composition informing the classification may be due to the five year gap between the surveys. ImoS, as present is infralittoral mobile sand and Spisula subtruncata and
Nephtys hombergii are species adapted to this habitat and therefore the SsubNhom classification close to the coast in 2010 is a result of more invertebrates in the grab samples than in 2005.

12.4.33 Outside of the GWF site boundary, two stations at the northern end of the survey area were tentatively classified as SS.SSA.CFiSa.EpusOborApri ‘Echinocyamus pusillus, Ophelia borealis and Abra prismatica in circalittoral fine sand’ on the basis of a sparse fauna but with at least one of the principal species found in the samples. This biotope is similar to SS.SCS.CCS.MedLumVen but is characterised by finer sediments and has a lower venerid bivalve component. It has been widely recorded in the central and southern North Sea (Connor et al., 2004).

12.4.34 The Ross worm Sabellaria spinulosa was a common organism recorded during the grab survey of the GWF site, but it was not evenly distributed. The highest abundances were found outside of the boundaries of the array area (see Figure 12.9). The species was also commonly recorded during the drop down camera survey of the site; again, the organism’s distribution was uneven with the highest abundances generally being found outside the revised boundaries (see Figure 12.10). There was a single station outside of the GWF boundary to the south-east of the wind farm development area where S. spinulosa dominated in possible reef form which led to the classification of SS.SBR.PoR.SspiMx Sabellaria spinulosa on stable circalittoral mixed sediment. Some of these areas have the potential to be considered reef (discussed in more detail in Paragraph 12.4.53 onwards).

12.4.35 S. spinulosa is widespread in sandy areas across the southern North Sea and is regularly found in benthic faunal samples (e.g. RPS, 2008). This species has been found in sufficient abundance to warrant the classification of a separate biotope at several other wind farms in the region: Inner Gabbard (CMACS, 2005a); Scroby Sands (Worsfold & Dyer, 2005) and Thanet (MES, 2005). One of the reference stations north of the export cable route was also classified as SS.SBR.PoR.SspiMx due to the abundance of S. spinulosa again in possible reef form.

12.4.36 The reference station to the south of the cable route comprised coarse sediment and the only fauna recorded was the bryozoan Electra pilosa. This site was classified as SS.SCS.ICS.SSh Sparse fauna on highly mobile sublittoral shingle (cobbles and pebbles), the only occurrence of this biotope in the survey.

12.4.37 In summary the only biotope of potential conservation interest recorded on the survey was the S. spinulosa dominated biotope. For further discussion of S. spinulosa see 12.4.53 onwards.
**Epifauna – regional context**

12.4.38 The MALSF REC project (MALSF, 2009) described epifaunal communities largely on the basis of epifaunal species taken from grab samples. The project found that none of the epifaunal assemblages across the area showed any geographical relationships and tended to correspond with coarser gravelly seabed sediment types (MALSF, 2009). With the exception of some of the slightly gravelly sand and shell sand substrates, which supported assemblages of the hydroid *Obelia bidentata* together with the almost ubiquitous hydroid Sertulariidae (MALSF, 2009), sandy sediments did not to support any epifauna. *O. bidentata* commonly occurs throughout UK waters and is typical of sandy sediments attaching to shells (Wilson, 2002). Sertulariidae encompass a suite of commonly occurring hydroid species found on a variety of surfaces and which can tolerate sediment influences such as sand scour (MALSF, 2009).

12.4.39 The principal epifaunal assemblage, in terms of spatial coverage across the Outer Thames Estuary REC, was associated with mixed slightly muddy sand and gravel sediments, the surfaces of the larger particles present being utilised as attachment sites (MALSF, 2009). The hydroids Sertulariidae are consistent components but are rarely associated with any other epifaunal species. Where they do occur, sea anemones, Actinaria and sea squirts *Molgula manhattensis* are found together with the Sertulariidae and form discrete sub-types of this assemblage (MALSF, 2009). The other species of sea squirt present, *Dendrodoa grossularia*, formed another small discrete assemblage (MALSF, 2009).

12.4.40 The Port of Felixstowe reconfiguration ES (Posford Haskoning, 2003) included marine ecological studies that extended to the western boundary of the GGOWF area. The epibenthic trawl survey undertaken during the reconfiguration EIA recorded the queen scallop *Chlamys* and pink shrimp *Pandalus montagui*, as well as the polychaete *Pomatoceros lamarcki* and a variety of bryozoan species as being common in the area. Other species present in relatively low abundance included, the green urchin *P. miliaris* the hermit crab *Pagurus bernhardus* and sea star *Asterias rubens*. Epibenthos recorded in the MALSF REC work (MALSF, 2009) included shrimps *Crangon allmani*, *C. crangon*, *P. montagui* and *Pandalina brevisrostris*, the brittlestar *Ophiura albida*, gobies *Pomatoschistus* spp., *P. miliaris*, and the flying crab *Liocarcinus holsatus*.

12.4.41 *Sabellaria spinulosa* is a UK BAP species, and where *S. spinulosa* forms reefs, this is regarded as an Annex I habitat feature under the EU Habitats Directive. There are no known occurrences of *S. spinulosa* forming stable reef structure in the proposed development area (MALSF, 2009; CMACS, 2010), the majority of *S. spinulosa* found within the Outer Thames Estuary REC was classified as clumps (i.e. nodules of reef <10 cm in diameter) and consequently were unlikely to constitute biogenic reef under the Annex I definition.
Epifauna – results of GWF surveys

Univariate analysis of epifaunal communities

12.4.42 Three site specific surveys (autumn 2008, spring 2009 and summer 2010) were undertaken to characterise the epibenthic faunal communities associated with the habitats present within the GWF site and export cable corridor. Analysis of the epibenthic community was carried out on both quantitative data (actual abundances) and qualitative data, where presence or absence of colonial or encrusting species was recorded. Comprehensive characterisation of the fish communities is provided in Chapter 13.

Autumn survey (October 2008)

12.4.43 A total of 18 epifaunal trawls were undertaken in October 2008, comprising eight within the wind farm site, four within the cable corridor route and six control sites adjacent to the development (Figure 12.8).

12.4.44 In the analysis of samples obtained from the beam trawl surveys 99 species were identified, 23 of which were fish species and 76 invertebrates. The results of the beam trawl sampling showed that of the quantitative taxa, the brittle star *Ophiura ophiura* was the most abundant accounting for 45% of individuals present. Overall, echinoderms represented 52% of individuals sampled (Plot 12.3). The next most abundant group were crustacean which made up 22% of sampled individuals (Plot 12.3) with the shrimp *Crangon allmanni* representing the most common species in this phylum and accounting for 9% of the total catch. Molluscs were the third most abundant group (15%) with the bivalve *Nucula nitida* representing 13% of the total individuals sampled. The most abundant annelids were *S. spinulosa* which accounted for 6% of individuals. Species from the gobies (Gobiidae) were the most abundant fish species found (see Technical Appendix 13.A).

Spring survey (April 2009)

12.4.45 A total of 18 epifaunal trawl routes were undertaken in April 2009, comprising eight within the wind farm site, four within the cable corridor routes, and six control sites adjacent to the development (Figure 12.1).

12.4.46 In the analysis of samples obtained from the beam trawl surveys 108 species were identified, 24 of which were fish species and 84 invertebrates. The brittle star species *Ophiura ophiura* and *O. albida* accounted for 25% and 18% of the echinoderm group which represented 51% of the total individuals recorded (see Plot 12.4). The next most significant group were crustaceans (42%) with the most dominant species being the shrimp *Crangon allmanni* which represented 16% of total individuals. The common dragonet *Callionymus lyra* and the lesser sandeel *Ammodytes marinus* were the most abundant fish species in the chordate group (see Technical Appendix 13.A).
Plot 12.3  Proportional representation of the major epifaunal groups present across the GWF site, based on semi-quantitative data (October 2008 beam trawls)

![Pie chart showing the proportional representation of the major epifaunal groups in October 2008. Echinodermata is the largest group at 52%, followed by Crustacea at 22%, Mollusca at 15%, Chordata at 4%, Annelida at 7%, and Other at 0%]

Plot 12.4  Proportional representation of the major epifaunal groups present across the GWF site, based on semi-quantitative data (April 2009 beam trawls)

![Pie chart showing the proportional representation of the major epifaunal groups in April 2009. Echinodermata is the largest group at 51%, followed by Crustacea at 42%, Mollusca at 2%, Chordata at 3%, Annelida at 1%, and Other at 1%]
Spring survey cable route only (March 2010)

12.4.47 A total of 3,227 individuals from 30 taxa were recorded in the six beam trawls along the cable route corridor.

12.4.48 The most abundant group identified were echinoderms accounting for 95% of the species sampled (see Plot 12.5). The dominant species within this group were the brittle star *Ophiura ophiura* which accounted for 86% of individuals sampled. The next most abundant group were crustaceans which were dominated by the shrimp *Crangon allmanni* representing 4% of total individuals caught (see Technical Appendix 12.A).

12.4.49 The majority of epifaunal animals were recorded in a single trawl (2,932 at Station T1, the station closest to the coast). This was exceptional compared to the other stations where there were less than 100 individuals per trawl and the lowest number of individuals recorded was just 6 at T3, mid-way along the export cable route. Results from GGOWF epifaunal survey indicate that the brittle star was only recorded at the trawl site closest to the shore (GGOWL, 2005).

Plot 12.5 Proportional representation of the major groups present along the GWF cable route, based on semi-quantitative data (cable route only March 2010 beam trawls)

Summary

12.4.50 The epifaunal survey results indicate that echinoderms (particularly brittle star species) were the dominant group around the wind farm site, cable route corridor and control area, followed by crustacea (primarily dominated by shrimp). The dominance of echinoderms was most pronounced along the cable route (95% of all species). It is also worth noting that the highest
numbers of epifauna individuals on the cable route survey were recorded at
the site closest to the shore.

12.4.51 There were limited differences between the autumn and spring surveys
although the numbers of shrimp were higher in the spring than the autumn.

12.4.52 Results are typical for the sediment type and similar to the results recorded at
GGOWF. Brittle star *O. ophiura* are typical of sands and muddy sands from
the shallow sublittoral to 200m whereas *O. albida* is found on a broader
range of sediment and was found at a greater number of sites in the trawl but
also in the grabs and seabed imaging.

**Sensitive species and / or habitats**

*Ross worm Sabellaria spinulosa*

12.4.53 The only benthic species of conservation concern identified within the GWF
area is the Ross worm *S. spinulosa*. Where the species forms reefs, these
are an OSPAR habitat which is in decline in the Greater North Sea area and
is therefore protected under Annex V of the OPSPAR Convention. This
species is also included in the UK BAP and is a sub-feature of the Habitats

12.4.54 *S. spinulosa* is a widespread species common to most sandy sediments of
the North Sea. It commonly forms aggregations of tightly packed individuals
living in close proximity and can reach densities of around 4000/m² in low
crustations of the seabed, known as reefs (Jackson & Hiscock, 2008;
Jones *et al.*, 2000).

12.4.55 Encrustations of the species are usually ephemeral in nature, commonly
forming and disintegrating (Jackson & Hiscock, 2008; Jones *et al.*, 2000)
through winter storm events and on occasion human activity (such as
demersal fishing activity (Jones *et al.*, 2000)). The UK BAP for *S. spinulosa*
reef notes that “crusts are not considered to constitute true *S. spinulosa* reef
habitats because of their ephemeral nature, which does not provide a stable
biogenic habitat enabling associated species to become established in areas
where they are otherwise absent”.

12.4.56 Under certain conditions where dense encrustations develop over time and
are not subject to disaggregation, the species can form a ‘biogenic reef’. Such features are of high ecological importance because of their ability to
provide complex habitat capable of supporting a number of other organisms
in what are commonly impoverished environments (i.e. they positively
contribute to biodiversity and ecosystem function).

12.4.57 As detailed in Paragraph 12.4.41, *S. spinulosa* was commonly recorded in
mainly individual form and on occasion in aggregations, during the GWF
benthic surveys. The highest abundances were found outside of the revised
boundaries of the GWF array areas (Figures 12.8 and 12.9). The species
was also commonly recorded during the drop down camera survey of the
site; again, the organism’s distribution was uneven with the highest abundances generally being found outside the revised boundaries.

12.4.58 It is noted that the JNCC have raised a comment during the Section 42 consultation relating to the inconsistency between \textit{S.spinulosa} records from camera and grab samples (see Table 12.1). Figures 12.8 and 12.9 show the records of \textit{S.spinulosa} recorded from grab and camera deployments respectively. It is important to note that the grab samples and camera surveys were undertaken at different locations around the GWF site (see Figure 12.1) in order to generate maximum and even coverage of the seabed. The drop down camera footage was only recorded at those grab sites where the grab was unsuccessful. It is considered that they show a similar pattern of occurrence, i.e. where a sample was recorded in a grab, the closest camera deployment to that site generally recorded presence as well. Any apparent discrepancy between results is likely to be as a result of the nature of the two sampling strategies and the patchy, localised occurrence of the species.

12.4.59 \textit{S.spinulosa} was unevenly distributed across the site at 29 stations, a total of 672 individuals were taken, with over half the total number recorded from station G51. Of the grab samples, only 3 stations show numbers of \textit{S. spinulosa} above 500m-1 (> 50 per grab), stations CG15, G60 and G51; G51 had over 3000 individuals m-1. Two of these stations (CG15 and G51) are outside of the site boundary. Of the drop down camera stations, 8 stations had abundant or extensive patches of \textit{S. spinulosa}. Of the abundant patches (stations CG9, CG14, G26 and G56) grab samples taken nearby showed that the number of individuals was low (with either none or 1-50 individuals taken in the grabs).

12.4.60 At stations where \textit{S. spinulosa} was extensive these were often low encrusting aggregations on the surface of gravel and larger particles. Camera images revealed larger aggregations at three stations:

- CG15 (reference station to the north of the export cable route) where there were free-standing aggregations approximately 15cm by 10cm in area and approximately 15cm high;
- C54 at the southern end of the eastern part of Area B where there were small aggregations on a sandy seabed and a large aggregation that almost fills the image but may be \textit{S. spinulosa} encrusted piddock-bored rock; and
- G44 to the east of Area B where there were common low encrustations on cobble and boulder with one very large aggregation which was not wholly captured in the image but is at least 20cm by 15cm on its longest axis (height uncertain)

12.4.61 Of relevance to subsequent assessments of habitat importance is whether the \textit{S. spinulosa} aggregations seen during the camera survey constitute biogenic reef. There are a number of studies which provide guidance on the extent of reefiness, including Gubbay (2007) and Limpenny et al. (2010).
Feedback from the IPC in the Scoping Opinion recommends the usage of the latter study (IPC, 2010).

12.4.62 The site survey reporting for the GWF benthic work was undertaken prior to Limpenny et al. (2010) guidance and therefore used Gubbay (2007) for assessing reefiness of *Sabellaria*. The following paragraphs have interpreted the findings from CMACS (2010) in light of the Limpenny et al. (2010) guidance.

12.4.63 Using Gubbay (2007) as a guide, there is a possibility that the observations at stations CG15 and G44 (neither of which are within the proposed GWF site boundary) constitute ‘low’ reef as the aggregations are raised from the seabed and are distributed over a large area (hundreds of m²) but overall seabed coverage is low (≤10%). The difficulty is that since these areas have not yet been monitored over time, it is impossible to tell whether these are fragments of larger aggregations that have been dispersed by trawling (trawling scars were apparent in the results of the geophysical surveys (Osiris Projects, 2010)) or whether these are new aggregations that, if left undisturbed, may become more prominent reef in the future.

12.4.64 It is worth noting that in the images from Station G44, the tops of the larger sediment particles have remnants of tubes with a dense coverage of intact tubes around the sides of particles. This may be a result of trawl damage or could simply be disturbance owing to seabed mobility (from storm events or long-terms physical processes).

12.4.65 Locations where there was extensive coverage of *S. spinulosa* aggregations were compared with sidescan sonar images from the geophysical survey to identify if any seabed bathymetry features could be associated with aggregations of *S. spinulosa* (CMACS, 2010).

12.4.66 Six locations where there was extensive coverage of *S. spinulosa* were considered and a mottled area on sonar images indicating seabed relief (depicted by the red broken line box in Plate 12.1) in the vicinity of Station G26 (southern part of Area A) was cross-referenced with grab data and seabed images which confirmed the presence of *S. spinulosa* (although in low abundance and therefore not identified as potentially important by grab or camera survey alone). The benthic images show a highly variable seabed with patches of coarse sand and shell in ripples as well as gravel and fine sand with small clusters of *S. spinulosa*. This suggests that there may be a relatively large area of patchy aggregations at low density in the south of Area A.

12.4.67 At the remaining five stations, however, sonar images showed little raised topography of note (e.g. Station 51, Plate 12.2) and therefore the *S. spinulosa* seen appear to be discrete crusts that are not part of a larger seabed form.
12.4.68 *S. spinulosa* is a sessile organism and is vulnerable to disturbance; the greatest impact on the species when in reef form is due to physical disturbance from fisheries activities\(^3\) for example from trawl gear. Despite this sensitivity to disturbance, it is considered that *S. spinulosa* has a high recoverability rate following a disturbance event owing to the long breeding

\(^3\) [www.ukbap.org.uk](http://www.ukbap.org.uk)
period, long larval phase and relatively rapid initial growth in the first year of settlement of the *Sabellaria* genus (MES, 2007).

12.4.69 Given that *S. spinulosa* is known to have rapid initial growth, there is a possibility that it may colonise the site between the characterisation surveys and the start of construction period. The implications of this are dealt with in Section 12.5.

12.5 **Assessment of Impacts – Worst Case Definition**

12.5.1 For the purpose of the marine and intertidal ecology impact assessment, the worst case scenario, taking into consideration the options currently being assessed, is detailed in Table 12.3.

12.5.2 For this parameter (marine and intertidal ecology) the worst case scenario will comprise the design options that provide the maximum area of directly and indirectly affected seabed. Establishing the worst case scenario from the range under consideration (see Chapter 5) ensures that the assessment is focused on the maximum potential adverse impact that could arise from the development. Only those development parameters that are considered to have a material bearing on the impact under consideration are identified within Table 12.3.

12.5.3 The worst case scenarios identified below are also applied to the assessment of cumulative impacts. In the event that the worst case scenarios for the project in isolation do not result in the worst case for cumulative impacts, this is addressed within the cumulative assessment section of the Chapter (see Section 13.10).
<table>
<thead>
<tr>
<th>Impact</th>
<th>Realistic worst case scenario</th>
<th>Justification</th>
</tr>
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<tbody>
<tr>
<td><strong>Construction</strong></td>
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<tr>
<td>Physical disturbance of intertidal habitat</td>
<td>Trenching across the intertidal area to below MHWS where there will be up to three drilling sites for directional drilling, totalling 75m². Vehicular disturbance from vehicles associated with the preparation of the reception pit and directional drilling.</td>
<td>Provides for the maximum amount (spatial extent) of habitat disturbance.</td>
</tr>
<tr>
<td>Physical disturbance of subtidal habitat</td>
<td>Export cable installation via plough throughout export cable route (5m x 190km = 0.95km²)</td>
<td>The worst case scenario is established by defining the maximum amount (spatial extent) of habitat disturbance.</td>
</tr>
<tr>
<td></td>
<td>Cable installation via plough for inter and intra-array cables (300km x 5m = 1.5km²)</td>
<td>For foundation structures this is represented by the maximum number of structures (140 WTGs, three met masts and four ancillary structures) which will in turn result in the maximum level of disturbance from construction vessel support structures (anchors and jack-up legs)</td>
</tr>
<tr>
<td></td>
<td>Anchored construction vessels – up to 6 anchors per vessel (up to 4m² per movement)*</td>
<td>For export and inter/intra-array cabling the maximum footprint is established through assumption maximum extent of cabling using the installation technique with the largest footprint). This is represented by the plough, which when considering it’s supporting feet has an approximate footprint width of 5m.</td>
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<td>Jack-up vessel - 6 legs of approximately 10m² per leg. Therefore, 60m² in total per movement with a representative maximum number of movements of six per foundation and met mast and eight for ancillary structures. Therefore, the total footprint based on a maximum number of 147 structures is 0.054km²</td>
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<td><strong>The total quantifiable construction disturbance is therefore is 2.5km²</strong></td>
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<tr>
<td>Impact</td>
<td>Realistic worst case scenario</td>
<td>Justification</td>
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<tr>
<td>Loss of subtidal habitat</td>
<td><strong>Habitat loss:</strong></td>
<td>The loss of subtidal habitat will result from the placement of built structures (and associated scour protection material) on the seabed. The worst case scenario is therefore, represented by the largest footprint from the foundation structures (and associated scour protection) under consideration.</td>
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<tr>
<td></td>
<td>101 * 45m Gravity base structure (GBS) foundations with scour protection applied to 100% of all foundations $\left(160,590m^2 + 174,730m^2 = 335,320m^2\right.$ ( (0.335km^2) ))</td>
<td>The GBS foundations have a larger footprint than any of the foundations under consideration. Of the GBS options for the WTGs, there could be up to 101 45m base diameter structures or 140 35m base diameter structures. Scour protection for 45m base diameter structures is 10m in radius around all structures and 9m around all structures for the 35m base diameter option. Therefore, the total footprint for the 45m base diameter option is 335,320m², whilst for the 35m option it is 308,856m². The 101 45m base diameter option therefore, has the largest overall footprint. For the met masts GBS options are considered and therefore, the 45m base diameter option presents the worst case.</td>
</tr>
<tr>
<td></td>
<td>Three met mast foundations on 45m GBS foundations including 100% scour protection $\left(4,770m^2 + 5,190m^2 = 9,960m^2 (0.01km^2)\right)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up to four ancillary structures (this may comprise a combination of offshore substation platforms (OSP), collection platforms and / or accommodation platforms) on space frame (self-jacking suction can) foundations (four leg jackets) assuming 100% scour protection $\left(18,748m^2 (0.019km^2)\right)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rock placement for cable protection at a total of 9 export cable crossings $\left(3,240m^2\right)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total area</strong> $= 0.335 + 0.01 + 0.019 + 0.003 = 0.37km^2$</td>
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</table>
### Realistic worst case scenario

<table>
<thead>
<tr>
<th>Impact</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased 101 (45m base diameter) GBS foundations for WTG structures, three (45m base diameter) GBS foundations for WTG structures</td>
<td>The ‘worst case’ scenario is represented by that which For the ancillary structures, only space frame (piled, suction can and self-jacking) and monopile foundations are considered. The area for a single self-jacking (suction can) space frame foundation (based on up to four legs) with 100% scour protection is 4,687m². For the four foundations this equates to a total area of 18,748m². The area for a single (piled) space frame foundation (based on up to six legs (3m diameter) each with up to two (3m diameter) pin piles) is 85m². The piled space frame requires 100% scour protection (with an additional 5m radius around each structure) the area of scour protection for four space frame structures is therefore 9,388m². A 7m monopile has a footprint of 38.5m² with a scour protection footprint of 1,700m² and therefore an overall footprint of 1,739m² (total area of 6,956 m² for four foundations). All other foundation types considered (Chapter 5) would result in a smaller loss of habitat.</td>
</tr>
</tbody>
</table>

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### Impact

<table>
<thead>
<tr>
<th>suspended sediments and mobilisation of contaminants</th>
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</table>

#### Realistic worst case scenario

- base diameter) GBS foundations for met masts, four 7m monopile foundations for ancillary infrastructure (totalling 500,800m³).

Seabed preparation for GBS comprises mechanical levelling of the seabed to a depth of approximately 2m.

- Turbine installation - two GBS foundations installed simultaneously over a three day period.

- Cable installation in the marine environment by jetting methods to install up to three export cables to a representative average of 1.5m depth, 0.5m width and a total of 190 cable kilometres in length. Inter and intra-array cabling will be a total length of 300 cable kilometres and have similar burial characteristics to the export cables.

#### Justification

- could result in the maximum volume of arisings (and therefore, maximum volume of material that could brought into suspension).

For the WTG foundations 101 (45m) GBS foundations represent worst case volume (484,800m³). Other options result in less volume released: 140 35m GBS foundation resulting in 445,340m³, 140 7m monopiles 224,000m³, 140 space frame foundations 182,000m³, 140 4-legged space frames founded with suction cans 43,960 m³ and 140 monopod buckets 70,000m³. For the met masts where all foundation types are available, again the 45m GBS foundations represent worst case. For the four ancillary structures, where GBS are not an option, the worst case is represented by the 7m monopile as this structure results in higher levels of spoil material (1,600m³ per foundation).

Ploughing, trenching and jetting were assessed by ABPmer (2011b), see Chapter 9 and Technical Appendix 9.Aiii, with jetting considered to represent the worst case scenario, the assumption being that all sediment disturbed would be fluidised and therefore, made available for re-suspension.
<table>
<thead>
<tr>
<th>Impact</th>
<th>Realistic worst case scenario</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance impacts on intertidal habitats</td>
<td>Unplanned maintenance operations requiring vehicular plant access to the buried cable during low water. Maximum potential area of disturbance would be as specified for construction phase.</td>
<td>Any maintenance activity required on the intertidal section of the export cables could require vehicular access. The worst case area of impact is therefore in line with that provided for under construction.</td>
</tr>
<tr>
<td>Indirect impacts on intertidal ecology from changes in current regime</td>
<td>No effect</td>
<td>Wave and tidal current effects are considered to be of limited magnitude being limited largely to within the vicinity of the turbine foundations. The local changes to the physical environment will therefore not cause any change to the wave and tidal current processes along the south-east England coastline (see Chapter 9).</td>
</tr>
</tbody>
</table>
| Maintenance impacts on subtidal habitat | Anchored construction vessels – up to 6 anchors per vessel (up to 4m² per movement)*  
Jack-up vessel – 6 legs of approximately 10m² per leg. Therefore, 60m² in total per movement* | Maintenance activity may impact on subtidal ecology if the plant used interacts with the seabed. The scenario therefore, provides for the maximum level of seabed disturbance from anchor and jack-up vessels. Use of dGPS vessels would not have an impact on the subtidal habitat.                                                                                                                   |
<p>| Indirect impacts on subtidal ecology from changes in current regime | 104 GBS foundations for WTG structures (see Section 9.5), three (45m base diameter) GBS foundations for met masts, four (7m) monopile foundations for ancillary infrastructure. Total volume of released material from scour of 446,864m³. | The indirect impacts on subtidal ecology are driven by scour events (from changes to current regime) around foundation structures and the subsequent release of sediments.                                                                                                                                                                                  |</p>
<table>
<thead>
<tr>
<th>Impact</th>
<th>Realistic worst case scenario</th>
<th>Justification</th>
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<tbody>
<tr>
<td></td>
<td>No scour protection measures.</td>
<td>GBS foundation options provide for maximum potential scour as a consequence of the larger surface area and hence interaction with hydrodynamic flows (see Technical Appendix 9.Aiii).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>104 x 45m diameter GBS foundations result in the release in 432,952m$^3$ of sediment while 143 x 35m diameter GBS foundations result in 65,231m$^3$ of sediment release.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Individual foundations sediment release rates via scour:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45m GBS = 4,163m$^3$; 35m GBS = 1,517m$^3$; 7m Monopile = 3,478m$^3$; space frame (jacket) = 1,097 m$^3$ (see Technical Appendix 9.Aiii)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Therefore, 104 conical 45m diameter GBS foundations (WTGs and met masts) and four monopile foundations (ancillary structures, which can only use monopiles or space frame foundations) represent the ‘worst case’ scenario</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This scenario results in the release of 446,864m$^3$ of materials with maximum suspension of fine sediment during operation due to scour effects at the turbine structures.</td>
</tr>
</tbody>
</table>

<p>| Alteration of | As per indirect impacts on ecology from changes to current regime detailed | As per indirect impacts on ecology from changes to current regime detailed |</p>
<table>
<thead>
<tr>
<th>Impact</th>
<th>Realistic worst case scenario</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>subtidal habitat from changes in current regime</td>
<td>above</td>
<td>regime detailed above.</td>
</tr>
<tr>
<td>Indirect impacts from alteration to human activities</td>
<td>Application for 50m safety zones around the maximum number (147) of WTGs, met masts and ancillary structures.</td>
<td>Maximum area from which other human activities will be excluded.</td>
</tr>
<tr>
<td>Creation of new habitats (colonisation of structures)</td>
<td>101 * 45m Gravity base structure (GBS) foundations with scour protection applied to 100% of all foundations $(160,590m^2 + 174,730m^2 = 335,320m^2 \ (0.335km^2))$</td>
<td>Aligned with seabed footprint (see loss of habitat in construction phase). The scenario provides for the maximum available surface area for colonisation, any other scenario will result in a lower surface area.</td>
</tr>
<tr>
<td></td>
<td>Three met mast foundations on 45m GBS foundations including 100% scour protection $(4,770m^2 + 5,190m^2 = 9,960m^2 \ (0.01km^2))$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up to four ancillary structures (this may comprise a combination of offshore substation platforms (OSPs), collection platforms and / or accommodation platforms) on space frame (self-jacking suction can) foundations (four leg jackets) assuming 100% scour protection $= 18,748m^2 \ (0.019km^2))$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rock placement for cable protection at a total of 9 export cable crossings $(3,240m^2)$</td>
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</tr>
<tr>
<td><strong>Total area</strong></td>
<td>$= 0.335 + 0.01 + 0.019 + 0.003 = 0.37km^2$</td>
<td></td>
</tr>
</tbody>
</table>

Decommissioning
<table>
<thead>
<tr>
<th>Impact</th>
<th>Realistic worst case scenario</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact on intertidal ecology</td>
<td>Removal of up to three export cables.</td>
<td>Arrangements associated with decommissioning will be determined prior to construction and a full Decommissioning Plan for the project will be drawn up and agreed with DECC. Until the arrangements have been clarified, the worst case scenario is that all structures will be removed.</td>
</tr>
<tr>
<td>Impact on subtidal habitat</td>
<td>Removal of all cabling and build structures (based on worst case assumptions detailed under construction).</td>
<td>Arrangements associated with decommissioning will be determined prior to construction and a full Decommissioning Plan for the project will be drawn up and agreed with DECC. Until the arrangements have been clarified, the worst case scenario is that all structures will be removed.</td>
</tr>
</tbody>
</table>

*The overall footprint area from anchoring activities will depend on a large number of variables including weather and ground conditions.*
12.6 Assessment of Impacts during Construction

12.6.1 There will be direct and indirect impacts due to construction. Direct impacts will be caused by activities that come into contact with the benthos (i.e. placement of plant or infrastructure) with indirect impacts caused by changes to the physical conditions (i.e. changes in suspended sediments or the tidal regime) which may have impacts away from the immediate construction location.

Direct impact on intertidal ecology due to physical disturbance

12.6.2 As discussed in Chapter 5, the export cables will be connected to the onshore transition bays through a technique known as directional drilling. Directional drilling is a steerable trenchless method of installing underground pipes, conduits and cables in a shallow arc along a prescribed bore path by using a surface launched drilling pit, with minimal impact on the surrounding area.

12.6.3 It is expected that up to three drilling sites (one for each export cable) for the directional drilling, and three reception pits will need to be established above the intertidal zone at the landfall location, in a similar fashion to installation of the cables for the GGOWF. As the exact location of the intertidal drilling site is unknown at this time, for the purposes of the impact assessment, it is assumed that the activity will all take place below MHWS. The footprint of one intertidal drilling site will be no more than 25m² per cable.

12.6.4 From Mean Low Water (MLW) up to the point of the reception pits, the cable will be installed via either ploughing or trenching, and from the reception pit the cable will be pulled through to the transition bay. The drilling site and intertidal cable trench will be backfilled upon completion. Construction of the drilling site and reception pit will necessitate some vehicular access across the intertidal zone to the site (for example for 20 tonne tracked 360 degree excavators).

12.6.5 Impacts on the habitats above MHWS (including the vegetated shingle) are discussed in Chapter 23, whereas impacts on the habitats below MHWS are discussed below.

12.6.6 The intertidal area within the vicinity of the landfall location is dominated by barren littoral shingle on the upper shore and barren littoral coarse sand on the lower shore (Table 12.4). The shingle and sand are not known to support any species of conservation concern. These habitats are typical in the region and throughout the UK and often exposed to high levels of sediment disturbance. Barren sand (LS.LSa.MoSa.BarSa) for example, has a very low sensitivity to physical disturbance and very high recoverability (Budd, 2008a). The damage to marine infauna within the footprint of the drilling site and vehicle access routes will therefore be short term as recovery is expected to happen quickly.
12.6.7 Given the ubiquity and recoverability of the communities present, their low sensitivity and the small area of intertidal environment likely to be disturbed by cable installation and vehicle access routes and therefore low magnitude of impact, it is anticipated that the impacts on intertidal ecology will be of negligible significance.

**Mitigation and residual impact**

12.6.8 Best practice measures will be employed by GWFL, based on lessons learnt from the GGOWF construction, to ensure that the significance of potential impacts remain as negligible, these include:

- The directional drilling reception pit footprint will be minimised so far as reasonably practicable, to avoid unnecessary excavation of the shingle;
- Tracking will be laid down across the shingle and intertidal area for the vehicles to drive across to minimise disturbance to the habitats (further detail provided in Chapter 23);
- During shingle excavation works, at the reception pit, shingle layers will be segregated and stored separately and replaced in the same sequence to retain any structural integrity of this habitat and minimise post-construction wash out of shingle; and
- Monitoring of the shingle / beach profile in the location of the reception pit following construction to identify any potential slumping and a need for future action.
Table 12.4  Sensitivity of intertidal biotopes identified at the GWF site

<table>
<thead>
<tr>
<th>Biotope</th>
<th>Definition</th>
<th>Value / sensitivity</th>
<th>Justification*</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS.LCS.Sh.Ba rSh</td>
<td>Barren littoral shingle</td>
<td>Low</td>
<td>Such shores tend to support virtually no macrofauna in their very mobile and freely draining substratum. The few individuals that may be found are those washed into the habitat by the ebbing tide, including the occasional amphipod or small polychaete. No macrofaunal life was noted and no species of any sensitivity / value were identified. Recoverability: Not assessed by MarLIN.</td>
</tr>
<tr>
<td>LS.Lsa.MoSa. BarSa</td>
<td>Barren or amphipod-dominated mobile sand shores</td>
<td>Low</td>
<td>Most of these shores support a limited range of species, ranging from barren, highly mobile sands to more stable clean sands supporting communities of isopods, amphipods and a limited range of polychaetes. No macrofaunal life was noted and no species of any sensitivity / value were identified. High recoverability from physical disturbance (Budd, 2008a).</td>
</tr>
<tr>
<td>LR.FLR.Eph</td>
<td>Ephemeral green or red seaweed communities</td>
<td>Low</td>
<td>These are biotopes with low species diversity and the relatively high number of species in the characterising species list is due to a variation in the species composition from site to site, not to high species richness on individual sites.</td>
</tr>
<tr>
<td>Biotope</td>
<td>Definition</td>
<td>Value / sensitivity</td>
<td>Justification*</td>
</tr>
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<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>(freshwater or sand-influenced)</td>
<td></td>
<td>No macrofaunal life was noted in any intertidal biotope, and no species of any sensitivity / value were identified.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unlikely to be disturbed due to location but typically high recoverability (Budd, 2008b).</td>
</tr>
</tbody>
</table>
12.6.9 The installation of cables and other wind farm infrastructure (foundations, WTG and ancillary structures) via jack-up barges, anchored vessels, ploughs etc will result in the temporary disturbance to the benthos. The disturbance will occur within the footprint of the cable installation, beneath the legs of the jack-up barges (predicted to equate to a maximum of 0.054km², see Table 12.3) and from the anchors of the construction vessels. The worst case scenario for cable installation is that cables will be installed via ploughing which will result in the disturbance of 0.95km² of habitat along the export cable route and 1.5km² of habitat in the inter and intra-array cables. Disturbance will take the form of displacement of sediment, depressions in the seabed and damage to or loss of the communities directly within the footprint of the works (Table 12.3).

12.6.10 Subsequently, the quantifiable worst case scenario for physical disturbance (Table 12.3) is an area of 2.5km² of subtidal habitat that will be affected, which is 1.1% of the total consent envelope area of 222km².

12.6.11 Whatever cabling method is chosen; it is likely that the benthos within the footprint of the installation will suffer some degree of disturbance during installation. However, given the largely ubiquitous nature of the benthic communities and their tolerance of disturbance the sensitivity would be low. Given that the works would be temporary the magnitude is considered to be low also and any impacts are expected to be minor adverse. Monitoring at the Kentish Flats Offshore Wind Farm of similar southern North Sea sandy communities has showed no evidence of significant seabed change caused by the cable installation (Emu, 2006 and Vattenfall, 2008).

12.6.12 Jack-up barge legs could be expected to create depressions in the seabed. Following construction, these depressions will be likely to back-fill naturally over time. For example, at Kentish Flats the smaller depressions have been observed to back-fill by an average of 0.2m over six months in similar types of sediments (Emu, 2006). Damage will occur to the infauna and epifauna within the footprint of the jack-up barge legs through compaction of the sediment.

12.6.13 The majority of the habitat that will be affected across the site comprises the deep Venus community (biotopes SS.SCS.CCS.MedLumVen and SS.SMX.OMx.PoVen). With the exception of S.spinulosa (although not present in the reef forming state), no species or habitats of conservation concern were recorded within the GWF boundaries and the infauna present in this region is generally sparse, of low density and species richness, and low biomass. Furthermore, the habitats recorded are generally widespread throughout the region. Whilst individual species may be sensitive to these direct impacts, the effects will be only temporary in nature and will be spatially distinct (i.e. the impact will not be repetitive at the same location). The species noted are also able to recover from physical disturbance (see Table 12.5).
12.6.14 Although *S. spinulosa* (biotope SS.SBR.PoR.SspiMx) was present at the site, no dense aggregations or reefs were recorded within the site boundary (Figure 12.9).

12.6.15 Following construction, the habitats and species are anticipated to recover. The majority of subtidal species and biotopes identified at the site (Table 12.5) exhibit good potential to recover, particularly to localised and short term disturbance of this nature. It is anticipated that the benthic community in the area impacted will recover to pre-impact levels and diversity following construction, with re-establishment boosted following the subsequent spawning and recruitment period to the activity. Monitoring studies at operational wind farms support this conclusion. At the Kentish Flats Offshore Wind Farm, post-construction benthic monitoring showed that any changes in the benthos since the pre-construction baseline were indistinguishable from what would be expected due to natural change (Vattenfall, 2008). Likewise studies at the Egmond aan Zee wind farm in The Netherlands comparing the macrofauna inside the wind farm with six reference areas showed that there were no major differences a few months after completion of the wind farm (Daan *et al* 2009). Some more disturbed areas may be slower to recover than others, for example, within the jack-up depressions or along the cable route, but it is anticipated that all areas will recover over time.

12.6.16 Given that only a small proportion (1.1%) of seabed within the GWF and cable corridor will be affected, the magnitude of the impact will be negligible. The species and habitats will recover quickly following construction, are widespread within the area and not of conservation concern and are therefore of low sensitivity. Therefore it is considered that this impact will be of negligible significance if *Sabellaria* is present in its reef form, this would be of higher sensitivity than the other habitats found at the GWF site and adverse impacts would potentially have greater significance. As discussed above it is not considered that any *Sabellaria* reef is at the site, however, pre-construction survey will be used to confirm this or determine any reef locations.

**Mitigation and residual impact**

12.6.17 Mitigation measures that will be adopted by GWFL in recognition for the potential for presence of *S.spinulosa* reef to develop prior to construction include:

- A pre-construction survey to determine the location of any reef forming *Sabellaria* within the proposed GWF site; and

- Micrositing of WTGs, ancillary infrastructure and cables, if pre-construction surveys were to identify any areas that are considered to constitute *S. spinulosa* reefs and subsequent consultation with the SNCA’s determined that planned installation plan would have a significant adverse affect on the reef feature.
12.6.18 With these mitigation measures in place the pathway for direct impact on \textit{S. spinulosa} reefs is removed and therefore \textbf{no impact} is predicted.
Table 12.5 Sensitivity of subtidal biotopes identified at the GWF site

<table>
<thead>
<tr>
<th>Biotope</th>
<th>Definition</th>
<th>Value / sensitivity to disturbance</th>
<th>Justification</th>
<th>Occurrence at site</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS.SCS.CCS. MedLumVen and SS.SMX.OMx. PoVen</td>
<td>“Mediomastus fragilis, Lumbrineris spp. and venerid bivalves in circalittoral coarse sand or gravel” and “Polychaete-rich deep Venus community in offshore mixed sediments”. Collectively represent the “Deep Venus Community”</td>
<td>Low to Medium</td>
<td>The recoverability of Venerid bivalves, depending on the species, ranges from low to medium, due to their long life and slow growth (Rayment, 2008). The polychaete <em>Mediomastus</em>, has a relatively large number of eggs and a planktonic larval phase, thus has a medium to high recoverability. <em>Lumbrineris</em> has a low recoverability due to no larval dispersal phase and slow growth.</td>
<td>Dominant, covering the majority of the seabed at Areas A, B and C</td>
</tr>
<tr>
<td>SS.SCS.CCS. PomB</td>
<td>‘Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles’</td>
<td>Negligible</td>
<td><em>Pomatoceros</em> has a long larval phase and early maturation, suggesting strong recoverability potential. Barnacles present in this biotope (<em>Balanus</em> sp.) have high dispersal and colonisation potential, and thus strong recoverability potential (Tyler-Walters, 2008).</td>
<td>Outlying stations (some areas within the wind farm boundary) and a large proportion of the cable route</td>
</tr>
<tr>
<td>SS.SSa.CFiSa.EpusOborApi</td>
<td><em>Echinocyamus pusillus</em>, <em>Ophelia borealis</em> and <em>Abra prismatica</em> in circalittoral fine</td>
<td>Low</td>
<td>Biotope is similar to MedLumVen (Deep Venus community) but is characterised by finer sediments and has a lower venerid bivalve component, suggesting a lower sensitivity.</td>
<td>Northern end of survey area (outwith wind farm boundary)</td>
</tr>
<tr>
<td>Biotope</td>
<td>Definition</td>
<td>Value / sensitivity to disturbance</td>
<td>Justification</td>
<td>Occurrence at site</td>
</tr>
<tr>
<td>---------</td>
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</tr>
<tr>
<td>sand</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SS.SSa.IMuSa.SsubNhom</td>
<td>‘Spisula subtruncata and Nephtys hombergi in shallow muddy sand’</td>
<td>Low</td>
<td>This is a sandy biotope with species of strong recoverability potential.</td>
<td>Inshore portion of cable route</td>
</tr>
<tr>
<td>SS.SSa.IFiSa.NcirBat</td>
<td>‘Nephtys cirrosa and Bathyporeia spp. in infralittoral sand’.</td>
<td>Low</td>
<td>This is a sandy biotope with species of strong recoverability potential (Budd, 2008c).</td>
<td>East side of survey area, partly within the wind farm boundary</td>
</tr>
<tr>
<td>SS.SCS.ICS.SSh ‘</td>
<td>Sparse fauna on highly mobile sublittoral shingle (cobbles and pebbles)</td>
<td>Low</td>
<td>Sparse fauna in this biotope suggests negligible sensitivity.</td>
<td>Reference station to the south of cable route</td>
</tr>
<tr>
<td>SS.SBR.PoR.SspiMx</td>
<td>‘Sabellaria spinulosa on stable circalittoral mixed sediment’</td>
<td>Medium, except where considered to be biogenic reef, where it is of high sensitivity</td>
<td>S. spinulosa contribute to biodiversity and ecosystem function by providing a consolidated habitat for epibenthic species. Where it forms reefs the value of the resource is increased. Reefs (including biogenic reefs created by S. spinulosa) are listed under Annex I of the Habitats Directive and S. spinulosa is a BAP species.</td>
<td>Presence of reef not confirmed this will need to be determined during pre-construction work with resurvey of potential reef areas.</td>
</tr>
</tbody>
</table>
Direct impact on subtidal ecology due to the loss of habitat

12.6.19 The installation of WTG, foundation structures and supporting infrastructure will result in long term loss of seabed and associated habitats and fauna within the footprint of the structures for the life of the scheme (circa 25 years).

12.6.20 Using the worst case build scenario detailed in Table 12.3 the maximum loss of seabed is anticipated to be 0.37km² (from WTG footprint, scour protection, ancillary structures and cable protection materials at cable crossings (see Table 12.3 for detail). The total area affected will constitute 0.17% of the total consent area (222km²). The majority of seabed lost will be as a result of the WTG foundations and associated scour protection.

12.6.21 Any reduction from the worst case in terms of materials required on the seabed will reduce the area of habitat loss.

12.6.22 The biotopes present at the site are discussed in Section 12.3. Table 12.5 summarises these biotopes and assesses their value and sensitivity.

12.6.23 The majority of the area that will be affected consists of a SS.SCS.CCS.MedLumVen and SS.SMX.OMx.PoVen. No protected or notable species were recorded within these biotopes. These biotopes are not confined to the GWF site boundary, and have also been found outside the proposed development area during the benthic survey. At a regional scale they are widespread and was found to be the principal biotopes on the GGOWF site and the London Array site (CMACS, 2010) to the south of the GWF and GGOWF sites.

12.6.24 Of the species and biotopes recorded during the survey, the only one of potential conservation interest is the widespread S. spinulosa, which was recorded in significant numbers at only one site, located outside the GWF boundary. No records of S. spinulosa reef were recorded within the proposed GWF site (see Section 12.4).

12.6.25 The majority of the communities that will be affected (such as the deep Venus community including biotopes SS.SCS.CCS.MedLumVen and SS.SMX.OMx.PoVen) are widespread at a regional level and even for the worst case scenario footprint the loss of habitat represents only a very small proportion of the expansive areas used by these communities.

12.6.26 Therefore, the magnitude of the impact upon these communities and features will be negligible. Given that they are of low sensitivity, the overall significance impact upon them will be negligible.

12.6.27 The direct loss of S. spinulosa reef as a habitat is considered under direct physical impacts, discussed above.

Indirect impacts on subtidal ecology due to increased suspended sediments

12.6.28 Increased suspended sediment load has the potential to impact on marine benthos through blockage to the sensitive filter feeding apparatus of certain
species and / or smothering of sessile species upon deposition of the sediment.

12.6.29 The activities which could lead to increased suspended sediment concentration (SSC) and subsequent elevated sedimentation will occur intermittently over the 56 month construction window (Chapter 5).

12.6.30 The levels of anticipated suspended sediments from the construction process are detailed in Chapter 9. The spatial plume predicted during installation of the WTG foundations has been modeled for both fine sands and coarse material based on the worst case of 7,200m$^3$ of material released from each GBS foundation due to seabed leveling work prior to installation (see Chapter 9). It should be noted that since the modeling was undertaken, further design optimisation has been undertaken and the predicted amount of sediment that could be brought into suspension from the mechanical leveling associated with the installation of each GBS foundation has been reassessed and reduced to 4,800m$^3$. This reduction in volume has been brought about through design optimisation.

12.6.31 As detailed in Table 12.3, based on the assumption that as a worst case 4,800m$^3$ of sediment could be brought into suspension during foundation installation will result in a total volume of 500,800m$^3$ of material to be deposited within the array in the worst case of 101 (45m) GBS foundations, three (45m) met mast foundations and four 7m monopile foundations for the ancillary infrastructure.

12.6.32 The dispersion and deposition of suspended sediments from construction activity have been modeled (ABPmer, 2011) and are discussed in Chapter 9. The model was run for approximately 15 days (over a spring - neap cycle), and assumed that 10 (2 * 5) GBS structures would be installed in this period, based on the deployment philosophy of a maximum of two GBS foundations installed at any one time (each one taking 3 days to install) (as detailed in Chapter 5).

12.6.33 With regard to the potential increase in SSC as a result of foundation installation activities, the studies undertaken by ABPmer (2011, also see Section 9.6 of Chapter 9 and Appendix 9.Aiii) indicate that SSC would be highest close to the point of foundation installation (0.5-1.4mg/l above background levels) for fine sands as a result of their lower sediment transport potential due to their increased size. The dispersal of sediment occurs along the main axis of tidal current flow (south-west to north-east) with elevated concentrations being of short-term, duration, typically lasting for only three days as per phase of installation. Figure 9.8 and Figure 9.9 (see Chapter 9) indicate that under all tidal conditions the majority of the suspended sediment dispersal will be limited to within Area A (the modeled area).

12.6.34 The elevated suspended sediment concentrations resulting from GBS foundation installation will be localised but last for a medium term (order of
months) assuming that the installation activities occur for a 152 day period (three days per foundation with two foundations installed simultaneously).

12.6.35 The maximum distance of the increased SSC levels can be observed approximately 15km from the export cable route; however the concentrations at these distances from the cable route are typically less that 0.2 mg/l. Results show that the SSC values, at a time of peak flow, remain less than 0.5 mg/l above natural background levels, with the greater magnitudes typically observed for the larger sediment sizes (ABPmer, 2011).

12.6.36 The suspended sediments arising from the cable installation of export, inter and intra-array and export cables within the wind farm array will be a short term effect, as the installation of cables will be episodic over a 56 month construction window (see Chapter 5). Actual periods of cable installation may extend due to occurrences of poor weather which may act to further disperse the sediment plumes and so restoring natural background levels.

12.6.37 Longer term dispersal will primarily be controlled by the tidal regime and as such will be along the dominant north-east to south-west axis, as noted to occur within the wind farm area. In shallower areas wave action will also play a role in acting to further disperse the suspended sediments.

12.6.38 Mobilised sediments from both the foundations and cables installation will be deposited on the seabed and the level of deposition depends on the sediment size and the dispersal of material within the Outer Thames Estuary and southern North Sea (ABPmer 2011). Figure 9.11 and Figure 9.12 (see Section 9.6 of Chapter 9) indicate the seabed deposition of different sediment sizes dispersed after the installation of the modeled 10 GBS foundations and export cable respectively. Bed thickness changes are greatest for the larger sediment as the tidal regime has less potential to transport this sediment size away from the site of mobilisation. The maximum bed thickness changes modeled is less than 35 microns (0.035mm) (equivalent to one grain of fine silt) in the wind farm area and less than 15 microns (0.015mm) along the cable route (see Section 9.6 of Chapter 9). Therefore, even with the levels of SSC increase from all of the GBS and cable installation activity, it is considered unlikely that sensitive species will be impacted by increased deposition of sediment from installation of foundations and the export cable route.

12.6.39 The seabed sediments across the GWF are predominantly sandy gravels with low concentrations of mud. Any fine sediment suspended during construction will only be a very small proportion (approximately 10%) of the overall sediment on the seabed. The majority of the sediment released will be relatively coarse and will most likely be re-deposited quickly and in close proximity to the works without prolonged suspension (see Section 9.6 of Chapter 9 and Technical Appendices 9.Aiii and 9.Aiv).

12.6.40 The biotopes present at the GWF site are typified by common polychaetes, bivalves and burrowing echinoids, which are tolerant of small, localised
increases in suspended sediment (Budd, 2008c, Tyler-Walters, 2008, Rayment, 2008) as would be expected given the levels of natural sediment disturbance at the site. The only species of conservation importance recorded at the site is *Sabellaria spinulosa*, however, this organism exhibits a level of tolerance to natural increases in SSC and short term smothering (OSPAR, 2010).

12.6.41 Given that the increase in suspended sediments will be temporary in nature, localised in scale and within the scale of natural variation\(^4\), the magnitude of the impact is considered to be low. The adaptability and tolerance of the species present to an increase in SSC (as frequently experienced under storm conditions within the study area, as detailed within Section 12.4) suggests that sensitivity is low to negligible. Consequently, the potential impacts arising from the temporary increase in suspended sediments on the marine benthic communities present is considered to be of negligible significance.

12.6.42 The species characterising the benthic communities present have a low sensitivity to smothering (Budd, 2008c, Tyler-Walters, 2008, Rayment, 2008). Given the temporary nature of the works and the widespread nature of the communities present in context with the localised footprint of significant deposition events, the magnitude of any impact will be low. Consequently, the potential impacts arising from the temporary deposition of material on the marine benthic communities present is considered to be of negligible significance.

*Indirect impacts on subtidal ecology through re-mobilisation of contaminated sediments*

12.6.43 Sediment disturbance during the construction phase of the proposed GWF project could lead to increases in sedimentation and subsequent remobilisation of contaminants held within the sediments. An increase in contaminants has the potential to impact the benthic communities.

12.6.44 As discussed in Chapter 10, sediment analysis has indicated that contaminant conditions for the area around the proposed GWF project are below levels at which adverse effects on the benthos are seen, with only elevated levels of arsenic detected from sampling and one sample with a level of mercury exceeding guideline levels (see Technical Appendix 12.A). Elevated levels of arsenic were detected at all stations and in one case at a level that is expected to cause adverse impacts on the benthos (see Section

\(^4\) SSC were measured at four locations as part of the Metocean data collection at GGOWF (see Chapter 9 and Technical Appendices 9.Aiii). The maximum concentration of suspended sediment was recorded as 85mg/l with a mean concentration of 20mg/l (ABPmer, 2011, see Technical Appendix 9.Aiii). Regional suspended sediment concentrations have been published by HR Wallingford *et al.*, (2002): offshore regional summer concentrations range from 1-10mg/l and winter concentrations from 1-20mg/l.
10.4. Arsenic is well known to occur at elevated levels in the region of the Outer Thames Estuary and has been attributed to both historic inputs and geological inputs.

12.6.45 Suspended sediment plumes and resultant deposition will be temporary, the SSC increases involved are small (0.5-1.4mg/l above background levels) and the footprint of impact will largely be restricted to the immediate vicinity of the works. Even for the fines, where the maximum distance of elevated SSC will be approximately 14km from the cabling activity; the concentrations at these distances are typically less that 0.2 mg/l (see Technical Appendix 9.Aiii). It is considered therefore that the magnitude of any impact will be low as the levels of potential contaminants released will be a fraction of the total suspended sediment. The species characterising the benthic communities have a low sensitivity to heavy metal contamination (Budd, 2008c, Tyler-Walters, 2008, Rayment, 2008). Therefore, it is anticipated that the impact of re-mobilised contaminants on the subtidal benthos will be of negligible significance.

12.7 Assessment of Impacts during Operation

12.7.1 There will be direct and indirect impacts on benthos due to operation. Direct impacts will be caused by activities that come into contact with the benthos (i.e. placement of plant) with indirect impacts caused by changes to the physical conditions (i.e. changes in suspended sediments or the tidal regime) which may have impacts away from the GWF infrastructure.

Direct impacts on intertidal ecology due to maintenance activities

12.7.2 Impacts on the intertidal zone during operation are considered unlikely as there will be no planned maintenance work on the cable. The only potential source of impact is therefore associated with the need to carry out emergency maintenance work around the reception pits or buried cable down to low water.

12.7.3 No sensitive communities have been identified in the intertidal zone below MHWS at Sizewell; subsequently it is considered that there will be negligible impacts on benthic communities due to maintenance activities.

Direct impacts on subtidal benthos due to maintenance activities

12.7.4 It may be necessary during the operational phase of the proposed GWF project to access the buried cables in the subtidal area for unplanned maintenance or repair, or access the turbines with jack-ups for unplanned maintenance activities which could all cause localised disturbance to the benthic assemblages directly surrounding the cable or WTGs. Maintenance may require the use of jack-up barges, anchored vessels or cable repair equipment depending on the nature of the work and the location (see Table 12.3). It is not possible to estimate how many vessel movements may be required for such exceptional maintenance over the operational life of the...
GWF. However, any disturbance will be of limited duration and the best practice guidelines will be followed to limit the disturbance.

12.7.5 During maintenance activities only a very small area of the seabed will be impacted at any one time, any disturbance will be short-term and sporadic and therefore the magnitude of this impact will be low. Given the recoverability of the species of the benthic communities, their sensitivity to these impacts is considered to be low. Therefore, it is considered that the potential impact on benthic communities due to maintenance activities will be of negligible significance.

12.7.6 If dense aggregations of *S.spinulosa* are identified within the GWF site during pre-construction survey, maintenance work required in the vicinity of these known aggregations will be conducted according to best practice and methodologies will be agreed with the regulators prior to commencement of works in order to minimise potential impacts. Given that no *S.spinulosa* aggregations that qualify as reef have been identified to date it is anticipated that there will be no impact of sensitive habitats. However, if high sensitivity reef is present, the low magnitude of impact during maintenance activities together with mitigation described above would result in a minor adverse impact at worst.

**Direct impacts on subtidal benthos due to habitat alteration**

12.7.7 The presence of the WTG and ancillary infrastructure foundations, scour protection (where utilised) and cable protection material will change the nature of the subtidal habitat. The impacts of the direct loss of the existing habitat are assessed as part of the impacts during construction (Section 12.6). The change will comprise the replacement of natural sedimentary seabed with steel piles, concrete foundations and scour protection material.

12.7.8 Following construction, the new surfaces will be available for colonisation by marine fauna. There is considerable literature documenting the colonisation of a very wide range of artificial structures at sea (Langhamer et al., 2009; Mirto and Danovaro, 2004; Bacchiocchi and Airoldi, 2003 and, Lindeboom et al., 2011). In many cases, such as the Horns Rev Offshore Wind Farm in Denmark, colonisation has been rapid, with a diverse assemblage of invertebrates present after just 6 months (GGOWL, 2005).

12.7.9 Colonisation could be expected to include seaweeds, mussels, barnacles, tubeworms, hydroids, sponges, soft corals, amphipods, anemones and other sessile invertebrates, as well as more mobile fauna including starfish and crabs (Emu, 2008), however the rate and sequence of colonisation is difficult to predict.

12.7.10 Clearly some degree of colonisation by marine organisms will also develop on any scour protection, particularly rock based protection. The presence of these structures will increase the surface complexity. Complex habitats provide a higher surface area for colonisation, protection from predators and shelter from stressful conditions such as intense water movement. Richer
and more diverse communities will therefore be likely in more complex structures.

12.7.11 Encrusting or tube-dwelling animals such as mussels, barnacles, and fouling amphipods will be likely to dominate the community, with a variety of larger mobile organisms such as starfish, crabs, prawns, shrimps and small fish expected, particularly on the lower parts of the structures and the scour protection.

12.7.12 Monitoring at Horns Rev indicated that within two years of the completion, the monopiles and scour protection were colonised by 11 species of algae and 65 invertebrate taxa. In addition the mobile invertebrates (decapods and molluscs) were found on the scour protection with the sessile species settling on the monopiles (Bio/Consult, 2004). At the Egmond aan Zee wind farm in The Netherlands (Daan et al., 2009), 33 species were found to have colonised the monopiles with 17 species on the scour protection after two years of monitoring.

12.7.13 There is potential for the alteration of habitat at the proposed GWF site to benefit the marine community of the area through colonisation of the structures being placed on the seabed. However, given the localised nature of such habitat alteration, and the scale of these changes in relation to the communities present in the wider area it is unlikely that the changes will result in any significant broadscale community or biodiversity changes. Furthermore, given the required minimum distances between the turbines and potential scour protection material it is not envisaged that the changes will constitute any form of linked reef-like feature. Therefore the magnitude of this impact is expected to be low.

12.7.14 Whilst increases in biodiversity could serve as a benefit to the receiving environment, in the context of this ES, any change from baseline conditions as a result of anthropogenic activity will not be considered to be a beneficial impact as it will reduce the “naturalness” of the area. However, given the ubiquity of the communities at GWF across the region it is considered that they have a low sensitivity to localised changes in community composition, therefore it is anticipated the impact on the subtidal environment due to the alteration of habitat will be of negligible significance.

Indirect impacts on intertidal ecology due to changes in coastal processes

12.7.15 Wave and tidal current effects are considered to be of limited magnitude being limited largely to within the vicinity of the turbine foundations. The local changes to the physical environment will therefore not cause any change to the wave and tidal current processes along the south-east England coastline (see Chapter 9). It is therefore considered that there are no pathways for impacts upon the intertidal communities and therefore there will be no impact on intertidal ecology during the operation.
Indirect impacts on subtidal ecology due to changes in current regime

12.7.16 **Table 9.6 in Chapter 9** identifies the worst case scenario with regard to operational effects on the hydrodynamic and consequently, sedimentary regime.

12.7.17 Based on the work carried out by ABPmer on GWF (see Technical Appendix 9.Aiii) and drawing upon experience from the adjacent GGOWF project, it is reasonable to assume that impacts on subtidal ecology due to changes in the current regime will be limited to sediment scour within close proximity to a small percentage of the foundations.

12.7.18 This scouring could have a direct and localised impact on the fauna within the footprint of the scour. The depth of scour will depend on the physical conditions, the thickness of the mobile layer and the cohesiveness of the substrate.

12.7.19 The geophysical survey undertaken for the GWF project clearly identifies the presence of scour in relation to natural seabed features within the GWF boundary (Osiris, 2010). Low mounds of granular sediments possibly formed from relict Pliocene ‘Crag’ deposits are associated with seabed scouring and in the GWF boundary scour is only present alongside these features in Area B. A number of wrecks were also noted in the geophysical survey data and the images provided of these wrecks would seem to suggest the presence of scour (Osiris, 2010).

12.7.20 An estimate of the depth and pattern of scour following installation of the WTGs at GWF was derived by ABPmer (ABPmer, 2011) for GBS foundations to determine how the seabed may be modified from its natural baseline state, and the volume and rate of additional sediment re-suspension resulting from scour. The results conservatively assume maximum equilibrium scour depths are present around the perimeter of the structure in a uniform and frequently mobile sedimentary environment. Scour pit volumes are calculated as the volume of an inverted truncate cone minus the volume of the structure itself.

12.7.21 Scour calculations for GBS foundations (45m diameter) at GWF predicted scour holes with dimensions of 6.3m to 15.8m across, dependent on tidal conditions (see Technical Appendix 9.Aiii that supports Chapter 9).

12.7.22 The maximum level of sediment volume released from scour development is no worse than that released through seabed preparation activities associated with the GBS foundation installation (4,752m$^3$ as compared to a maximum of 4,163m$^3$ for the scour associated with 45m base GBS structures).

12.7.23 It has been concluded that the potential effects upon the suspended sediment concentrations and bed level changes due to GBS foundation installation activities can be considered of negligible significance.
12.7.24 No sensitive communities have been recorded within the areas of the proposed GWF WTGs and the communities are widespread throughout the area and the region.

12.7.25 It has been assumed (see Chapter 5) that should GBS foundations be used then all would be subject to scour protection and subsequently scour of the level described above would not occur (see Chapter 9, Section 9.7). For other foundation options the level of scour protection would be commensurate to the level of scour risk posed by the option (as detailed in Chapter 5).

12.7.26 Therefore, significant scour events will be avoided by the use of scour protection; consequently large scour pits around foundations will not develop. Scour will be limited to secondary scour around the scour protection itself, which will be substantially lower than that described above for an unprotected scenario (which will never occur). The volume of material and area of any secondary scour will be determined in the scour protection plan that will be undertaken prior to construction, based on further survey and detailed design.

12.7.27 Any impact will be a long term impact for the life of the scheme (circa 25 years). Given the small area of seabed affected in relation to the extent at which these communities occur and the lack of sensitive features it is anticipated that the significance of scour effects will also be likely to be negligible at worst.

Mitigation measures

12.7.28 The level of impact from scour on the marine benthic ecology would be reduced to no impact under a GBS scenario. There is the potential that if monopile solutions were used and 10 percent of foundations were protected (where deemed most susceptible to scour events), that scour could occur around an unprotected structure. Consequently, the residual impact would be restricted to a limited number of structures and on a smaller scale to the maximum predicted under an unmitigated GBS scenario. As the potential for impact will not be removed by the mitigation under all development scenarios the residual impact is considered to remain at negligible significance.

Indirect impacts on subtidal benthos due to alteration to existing human activity

12.7.29 Commercial beam trawling activities currently occur within the GWF boundary, (further detail on fisheries utilising the area is provided in Chapter 15 Commercial Fisheries). This type of activity can alter habitats leading to less diverse habitats dominated by short lived, opportunistic species (Jennings and Kaiser, 1998).

12.7.30 Whilst fishing activity will not be excluded within the GWF site, it is possible that trawling activity will reduce due to concerns about health and safety with the increased risk of collision with wind farm structures. This may have a
subsequent impact on the marine benthos. Whilst vessels will be able to enter the GWF site during operation, 50m exclusion zones will be applied for around the WTGs where access will not be permitted (refer to Chapter 5). Overall, the level of fishing activity will be likely to reduce, however this is difficult to quantify and needs to be seen in the context of larger industry level impacts from changes in quotas and economics which may also affect the level of fishing activity. In addition, consultation with some UK based operators did not indicate a reluctance to enter the GWF site once operational, however there are concerns surrounding health and safety and insurance costs (for a detailed assessment of implications for commercial fisheries see Chapter 15).

12.7.31 This reduction in fishing activity could aid in the recovery of areas and the development of habitats of higher diversity and complexity. However, due to the uncertainties surrounding the change in fishing activity, the potential for a beneficial impact upon benthic ecology cannot be confirmed at this stage. It is anticipated that the subsequent impact on the subtidal will be of negligible significance.

12.8 Impacts during Decommissioning

12.8.1 As stated in Table 12.3, the final decommissioning proposals will be established prior to construction in agreement with the MMO and relevant SNCAs and stakeholders. Options at the end of the operational lifetime of GWF include removal of all infrastructure, leaving cables in situ but removal of all foundation structures and scour protection (or repowering which would be considered under a separate consenting process). As a precautionary worst case scenario for the purposes of this assessment it is assumed that all GWF infrastructure will be removed as this would lead to the highest number of boat movements, duration of activity and disturbance to the seabed.

Impact on intertidal ecology

12.8.2 It is expected that burial depth will be an important factor in helping to determine the appropriate course of action for removal of cables and will therefore be closely monitored throughout the project life-cycle. The removal of all intertidal cabling will result in impacts on intertidal ecology in line with those specified for construction in Section 12.6. Given the ubiquity and recoverability of the communities present, their low sensitivity and the small area of intertidal environment likely to be disturbed by cable removal and vehicle access routes and therefore low magnitude of impact, it is anticipated that the impacts on intertidal ecology will be of negligible significance.

Impact on subtidal ecology

12.8.3 It has been assumed that decommissioning will include the removal of all offshore structures, GBS foundations will be fully removed and piled foundations will be cut off at or just below the seabed. The removal of this infrastructure will necessitate the use of a heavy lift vessel. It is expected that burial depth will be an important factor in helping to determine the
appropriate course of action for removal of cables and will therefore be closely monitored throughout the project life-cycle. A typical cable removal programme will include the following:

- Identify the location where cable removal is required;
- Removal of cables, feasible methods include:
  - Pulling the cable out of seabed using a grapnel;
  - Pulling an under-runner using a steel cable to push the electrical cable from the seabed; or
  - Jetting the seabed material.
- Transport cables to an onshore site where they will be processed for reuse/recycling/disposal.

12.8.4 Impacts will be similar to those described for the construction phase (physical disturbance, smothering and re-mobilisation of contaminants), although these are likely to be lower in magnitude. Given the low sensitivity of the habitats in the area and the low magnitude of impact, the significance of the impact overall would be negligible.

12.8.5 In addition there will be the loss of any complex habitats developed on the hard substrate provided by the infrastructure, whilst over time the original habitats lost in the footprint of the infrastructure will redevelop. Overall, the long term effect of this would be to return the area to its former state and the impact would be neutral with no impact on the long term.

12.8.6 There is potential that sensitive features (such as S.spinulosa reef) not currently present may develop within the area during the operational period. If these have developed, it will be necessary to discuss how to decommission the wind farm with the regulators. From a precautionary standpoint, therefore, there may be minor adverse impacts during the decommissioning phase.

Mitigation and residual impact

12.8.7 It is anticipated that surveying for Annex I habitat will be undertaken prior to decommissioning in line with those anticipated pre-construction (see Section 12.6). Should these surveys indicate the presence of any sensitive habitats (such as S.spinulosa reef), GWFL will discuss how to decommission the wind farm with the regulators to avoid, where possible, impacts upon such habitats. Subsequently, in light of such mitigation measures the residual impact on the subtidal benthos from decommissioning will be of negligible significance.

12.9 Inter-relationships

12.9.1 The inter-relationships between the marine and intertidal ecology and other physical, environmental and human parameters are inherently considered throughout the assessment of impacts (Sections 12.6 and 12.7) as a result of the receptor lead approach to the assessment. For example, marine ecology has the potential to be influenced by increases in suspended
sediments as a result of effects on physical processes from the proposed development. The potential impacts as a result of this indirect effect have been discussed within this chapter based on the findings of the assessments made in Chapter 9 Physical Environment and Chapter 10 Marine Water and Sediment Quality.

12.9.2 Similarly any impact on the marine and intertidal ecology from the proposed development has the potential to impact on a number of other receptors, such as fish resource and ornithology. The information provided in this Chapter is used in turn by these relevant receptor lead Chapters to establish the potential for and significance of inter-related impacts.

12.9.3 Table 12.6 summarises those inter-relationships that are considered of relevance to the intertidal and subtidal benthic communities and, identifies where within the ES these relationships have been considered.

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<th>Inter-relationship</th>
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<th>Linked Chapter</th>
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<tr>
<td>Indirect impacts on marine ecology from increased suspended sediments and or contaminants</td>
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<td>Influencing parameter: Chapter 9 Physical Environment and Chapter 10 Marine Water and Sediment Quality</td>
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<td>Indirect impacts on marine ecology and habitat from changes to physical processes</td>
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**12.9.4 Chapter 29 Assessment of Inter-relationships** provides a holistic overview of all of the inter-related impacts associated with the project.

**12.10 Cumulative Impacts**

**12.10.1** The unmitigated impacts identified during the construction (Section 12.6) operation (Section 12.7) and decommissioning phases (Section 12.8) of the GWF project that could result in cumulative impacts comprise:

- Loss of subtidal habitat;
- Physical disturbance from construction vessels and cable installation;
- Indirect impacts due to increased suspended sediment;
- Indirect impacts through changes in the tidal current regime;
- Direct impacts on benthos due to maintenance activities;
- Direct impact on subtidal benthos due to habitat alteration; and
- Indirect impact on subtidal benthos due to alteration to existing human activity.

**12.10.2** Cumulative impacts associated with the proposed GWF project could occur on a number of levels:

- Interactions between different aspects of the proposed GWF project with other wind farms; and
- Interactions with other activities occurring in the region.

**12.10.3** The following paragraphs provide an assessment of the potential for cumulative impact over these varying levels.

**12.10.4** The assessment of the proposed GWF project alone has indicated that direct impacts (loss of habitat and physical disturbance) will occur within the footprint of the project and indirect impacts restricted to extent of sediment plumes (to the region of 15km, see Section 9.6 of Chapter 9).
12.10.5 Therefore, the proposed GWF project will only have the potential to have spatial overlap of impacts with those projects that lie within range of the indirect effects. However, given the widespread nature of the benthic communities present within the study area, consideration is also given to activities or developments that have the potential to impact on these communities throughout the region and consideration is given to the overall spatial footprint of these activities and developments.

_GWF and other wind farms_

12.10.6 **Table 12.7** lists the other wind farms in the Outer Thames Estuary Strategic Area which are of relevance to GWF.

12.10.7 With regard to construction impacts, these will only occur for those projects for which construction will overlap with that of GWF. Most of the potential impacts (physical disturbance, increases in suspended sediments and changes to tidal current regime) will be temporary, small scale and localised for GWF and this will be the case with other projects, construction impacts will therefore be of low or negligible magnitude. The only sensitive subtidal habitat in the region (_Sabellaria spinulosa_ reef) either does not occur or can be avoided by micrositing of infrastructure and best practice minimizing plant movements.

12.10.8 Given the distance between GWF and the other projects (with the exception of GGOWF) there will be no spatial overlap between increased concentrations of suspended sediments (given the findings presented in **Sections 12.6** and **12.7** above). There will however be a potential additive impact across the region, but given the magnitudes of impact involved and the low sensitivity of most habitats and species within the regional benthic community, the cumulative impact would be **negligible**.

12.10.9 The adjacent GGOWF project will have impacted a small area of intertidal environment but given the recoverability of the communities present it is likely that they will have recovered by the time GWF works are undertaken. Operational impacts would only be cumulative if maintenance works occur at the same time. Again though, given the small scale of any works and their temporary nature any cumulative impact would be of low magnitude. Given the low sensitivity of the habitats, any cumulative impact would be of **negligible** significance.

12.10.10 With regard to the long term loss of seabed in the footprint of the wind farm structures, the GGOWF ES (GGOWF, 2005) predicted, as a worst case scenario, that a total of 0.23% of seabed within the GGOWF project boundary will be lost (approximately 0.33km²). When this is added to the predicted losses of the GWF project (0.17%, approximately 0.37km²), the total percentage loss over both sites will be approximately 0.7km² of a total of 369km² covered by the two sites (approximately 0.19% of the combined area). This small scale loss in relation to the habitats and communities that are present will not result in impacts that are cumulatively any more significant than those which are predicted for the GWF alone. Although there
would be an aggregated direct and permanent loss of habitat during the operational phase of all of the wind farms (see Table 12.7) in the region it is anticipated that, given the ubiquity of the benthic communities across the southern North Sea, the magnitude of cumulative impact will be negligible (see Table 12.7). Overall given the low sensitivity of these communities, the overall significance of impact will be negligible.
Table 12.7 Existing projects (operational, under construction or in planning) within the Outer Thames Estuary Strategic Area

<table>
<thead>
<tr>
<th>Project (and Bidding Round)</th>
<th>Developer / Owner</th>
<th>Distance and direction</th>
<th>Area (km)</th>
<th>Loss of habitat (worst case with scour protection) (km²)</th>
<th>% of area</th>
<th>Status/timescale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater Gabbard (The Crown Estate Round (TCE R 2))</td>
<td>Greater Gabbard Offshore Winds Ltd</td>
<td>Immediately to the west</td>
<td>174</td>
<td>0.33</td>
<td>0.23</td>
<td>In construction, due to be operational in 2012</td>
</tr>
<tr>
<td>Gunfleet Sands I (TCE R1)</td>
<td>DONG Wind UK</td>
<td>43km to the south-west</td>
<td>10</td>
<td>0.001</td>
<td>0.007</td>
<td>Operational</td>
</tr>
<tr>
<td>Gunfleet Sands II (TCE R2)</td>
<td>DONG Wind UK</td>
<td>40km to the south-west</td>
<td>5</td>
<td></td>
<td></td>
<td>Operational</td>
</tr>
<tr>
<td>Gunfleet Sands Demonstrator</td>
<td>DONG Wind UK</td>
<td>40km to the south-west</td>
<td></td>
<td>Two WTGs within Gunfleet II area</td>
<td></td>
<td>Construction to begin during 2011/2012</td>
</tr>
<tr>
<td>Kentish Flats (TCE R1)</td>
<td>Vattenfall</td>
<td>64km to the south-west</td>
<td>10</td>
<td>0.0098</td>
<td>0.1</td>
<td>Operational</td>
</tr>
<tr>
<td>Kentish Flats Extension (TCE R2.5)</td>
<td>Vattenfall</td>
<td>64km to the south-west</td>
<td>7.8</td>
<td>0.0090</td>
<td>0.1</td>
<td>Construction to begin in 2013</td>
</tr>
<tr>
<td>Project (and Bidding Round)</td>
<td>Developer / Owner</td>
<td>Distance and direction</td>
<td>Area (km)</td>
<td>Loss of habitat (worst case with scour protection)</td>
<td>Status/timescale</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------</td>
<td>------------------------</td>
<td>----------</td>
<td>--------------------------------------------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td>London Array (TCE R2)</td>
<td>London Array Ltd</td>
<td>19km to the south-west</td>
<td>100</td>
<td>0.003*</td>
<td>Under construction: 2011 to 2012/13</td>
<td></td>
</tr>
<tr>
<td>Phase I</td>
<td></td>
<td></td>
<td></td>
<td>0.003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>London Array (TCE R2)</td>
<td></td>
<td></td>
<td>100</td>
<td>0.002*</td>
<td>Earliest possible construction in 2014/2015</td>
<td></td>
</tr>
<tr>
<td>Phase II</td>
<td></td>
<td></td>
<td></td>
<td>0.002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thanet</td>
<td>Vattenfall</td>
<td>37km to the south-west</td>
<td>35</td>
<td>0.002*</td>
<td>Operational</td>
<td></td>
</tr>
<tr>
<td>East Anglia ONE (TCE R3)</td>
<td>Vattenfall and Scottish Power Renewables</td>
<td>25km to the north-east (East Anglia ONE)</td>
<td>Not available</td>
<td>Not available</td>
<td>Earliest possible construction expected to begin in 2015</td>
<td></td>
</tr>
</tbody>
</table>

Source: The Crown Estate, www.4coffshore.com (08.09.11) and consultation with developers, published ESs

* Without scour protection, figures from Dong Energy, K. Henson pers comm..

+ No scour protection installed
12.10.11 With regard to direct impacts from maintenance activities, these will be restricted to the areas in the immediate vicinity of the works for routine maintenance; impacts will be highly localised and temporary. By following best practice impacts will be further minimised. At this juncture it is not possible to predict the scale of maintenance works required for GWF or indeed other sites, however given that these will be highly localised and temporary and therefore the magnitude of impact will be low. Overall given the low sensitivity of the benthic communities, the overall significance of impact will be negligible.

12.10.12 It is expected that direct impacts due to habitat alteration (i.e. development of fouling communities on the hard substrate provided by infrastructure) will again be highly localised to the WTGs and any scour protection. For GWF it is considered that this impact will be negligible and there will not be a true ‘reef’ created due to the distances between WTGs. Across the other wind farms the same will hold true, and therefore the area of habitat change within the wider region will be of negligible magnitude. Given that the benthic communities are ubiquitous across the southern North Sea they are considered to have low sensitivity, and therefore any cumulative impact would be negligible.

12.10.13 Indirect impacts during operation, such as scour, will also not be considered to have a cumulative impact as the scour was predicted to be highly localised and any increased suspended sediment through scour was predicted to be lower than that released during construction activities. Where scour may be experienced at WTG sites where mobile seabed sediment material is present then scour protection measures will be used and therefore the magnitude of habitat loss will be as described above (see Table 12.7) and the significance of impact will be negligible. Any scour below the level at which scour protection is required will clearly have a negligible impact.

12.10.14 Indirect impacts to the benthos due to alteration in human activities will be confined to any changes of fishing pressure due to the presence of the wind farms. Most wind farms, with the exception of London Array, currently allow fishing within them (apart from small areas associated with safety zones) so it is likely that if compatible fishing activities (i.e. those utilizing static gear) currently occur within a site these will continue. It is not possible at this juncture to determine what level of decrease in fishing activity may occur and what the subsequent indirect impact on the benthos will be, especially considering concurrent decreases in fishing capacity and potential for quota changes. However, given the area of the wind farms compared to the wider available area for fishing and the widespread nature of the communities across the region it is unlikely that there will be a significant cumulative impact due any reduction in fishing effort.

12.10.15 As detailed in Section 12.7 (and supported by the outcome of hydrodynamic modelling reported in Chapter 9 and associated Technical Appendix 9.Aiii) indirect construction and operational impacts will be localised to the immediate vicinity of the project. Potential pathways for indirect operational
impacts between the GWF project and other wind farm developments do not exist.

**GWF and other activities**

12.10.16 There are limited additional human activities occurring within the vicinity of the GWF project site, with the exception of aggregate extraction, which is discussed in more detail in Chapter 18 Other Human Activities. There are numerous aggregate extraction areas within the vicinity of the proposed GWF project, and those of potential relevance to the project are listed in Table 12.8.

**Table 12.8 Aggregate application, prospecting and license areas of potential relevance to the proposed GWF project**

<table>
<thead>
<tr>
<th>Name and number</th>
<th>Area type and status</th>
<th>Minimum distance from GWF</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Inner Gabbard – 498</td>
<td>Aggregate Application Area/Prospecting area</td>
<td>Adjacent to the northern boundary of export cable route (500m)</td>
</tr>
<tr>
<td>Shipwash - 507/1,2,3,4</td>
<td>Aggregate Application Areas</td>
<td>Four sites, between 9km and 14km to the west of the proposed GWF site</td>
</tr>
<tr>
<td>Shipwash – 507/5*</td>
<td>Aggregate Application Area</td>
<td>Within export cable corridor</td>
</tr>
<tr>
<td>Shipwash – 507/6</td>
<td>Aggregate Application Area</td>
<td>Approximately 1km to the south of the cable corridor</td>
</tr>
<tr>
<td>Longsand – 510/2</td>
<td>Aggregate Application Area</td>
<td>10.5km to the west of the proposed GWF site</td>
</tr>
<tr>
<td>Longsand - 510/1, 509/3 and 508</td>
<td>Aggregate Application Areas</td>
<td>14.9km to the west of the proposed GWF site</td>
</tr>
<tr>
<td>Inner Gabbard - 119/3</td>
<td>Aggregate Production License Area</td>
<td>6.8km to the west of the proposed GWF site</td>
</tr>
<tr>
<td>Longsand - 108/3</td>
<td>Aggregate Production License Area</td>
<td>14.5km to the west of the proposed GWF site</td>
</tr>
</tbody>
</table>

* With regard to Area 507/5 discussions are ongoing with CEMEX Marine UK Ltd in order to agree the final location of GWF export cables in relation to this area. In the meantime CEMEX has confirmed that it has no objections to GWFL submitting a planning application that includes reference to potential cable routes both in and adjacent to Area 507/5, subject to agreement (see Table 18.2 within Chapter 18).
12.10.17 Studies to support the GGOWF ES analysed the potential for cumulative effects between the foundation installation process at the GGOWF and aggregate dredging licences 452 and 119/3 (ABPmer 2005). The studies concluded that overlapping plumes would be unlikely to occur if aggregate dredging and foundation installation were synchronous. No cumulative effect was predicted. These conclusions are supported by the results of monitoring work by Oakwood Environmental Ltd (1999) who conclude that “whilst it was possible to track the plume from the dredger for up to 3.5km from the dredger, concentrations of sand sized and muddy material decayed to background levels between 300 and 500m downstream from the point of release, whilst coarse sands and gravels settled out almost instantaneously”.

12.10.18 Further numerical modelling studies undertaken by HR Wallingford (2010) for the Outer Thames MAREA concluded “that predicted SSC increases outside License Areas will be less than 20mg/l above background levels, except when dredging occurs close to the boundary”. Such concentrations are less than the increases which occur naturally as a result of tidal conditions and waves (HR Wallingford, 2010).

12.10.19 Given the distances to aggregate dredging sites it is likely that impacts from increase in SSC would only be cumulative for the nearest dredging sites. Given the small increases in SSC above background levels from GWF and aggregate dredging and the fact that these concentrations are less than increases caused by natural events, it is considered that any cumulative impact would be of negligible magnitude, which, given the low sensitivity of the benthic communities to increases in SSC and smothering effects would give a negligible impact overall.

12.10.20 There is however the potential for cumulative habitat disturbance impacts. In 2010, the total licensed area for aggregate extraction in the Thames Estuary area was 49.94km², of which 4.18 km² (8.5%) was actually dredged. For the East Coast region the total area actually available to be dredged was 158.17km², dredging actually took place within 36.85 km², 13.8% of the licensed area. High intensity dredging was restricted to 2.76 km², accounting for 52.8% of regional dredging activity (The Crown Estate and BMAPA, 2011). From these figures it can be seen that the actual areas of activity are small in comparison to the areas licensed and in any one year, again given the scale of this activity when compared to the southern North Sea, the magnitude of impact is negligible. Given the low sensitivity of the benthic communities, the overall impact from dredging will be negligible and any cumulative impact of habitat disturbance with GWF will be of negligible significance.

12.10.21 Sizewell Power Station has a number of existing marine components, comprising inlet and outlet pipes for both Sizewell A and Sizewell B (see Chapter 18). There are localised thermal plumes associated with the outlet pipes, however, their impact footprint is unlikely to overlap with that of the GWF cable works and therefore, potential for cumulative impact is considered unlikely. Sizewell also has expansion plans, although a formal
Scoping Report for Sizewell C has not yet been submitted. This development, if it were to go ahead, is likely to be to the north of the existing Sizewell infrastructure. Given the limited marine works (installation of inlet and outlet pipes) and the distance between the development and GWF, the potential for cumulative impact on either the intertidal zone and/or marine ecology is considered limited.

12.10.22 In light of the considerations relating to aggregate extraction activity and the Sizewell works, the cumulative impact on the marine and intertidal ecology interests from GWF with these activities is therefore considered to be negligible.

12.11 Transboundary Effects

12.11.1 This Chapter has considered the potential for transboundary effects to occur on marine and intertidal ecology as a result of the construction, operation or decommissioning of the proposed GWF project. In all cases it is concluded that the potential impacts arising, by virtue of the predicted spatial and temporal magnitude of the effects, would not give rise to significant transboundary effects on the environment of another European Economic Area (EEA) member state. A summary of the likely transboundary effects of the proposed GWF are summarised in Chapter 31 Transboundary Effects.

12.12 Monitoring

12.12.1 As detailed in Section 12.6 (physical disturbance) a pre-construction S. spinulosa survey will be undertaken to ensure that the species has not established reef habitat within the site boundary between the site surveys undertaken to inform this study (2009) and the start of construction, with particular focus around proposed locations for WTG foundations, scour protection and inter/intra-array and export cables. The methodology for this survey will be agreed in advance with the JNCC, Natural England and the MMO. The survey will be undertaken in sufficient time ahead of the start of the construction (at least four months) to ensure that the results can be reviewed and agreed by the relevant authorities prior to construction. Should any S. spinulosa reef or reef-like structures be identified in the area of the survey the appropriate course of action with regard to construction activity in these areas and any necessary micrositing of WTGs or ancillary structures will be agreed with the JNCC, Natural England and the MMO.

12.12.2 The requirement for, and detail of, any further pre and post construction monitoring at GWF (such as replicate infaunal and epifaunal sampling) will be established through consultation with the MMO, JNCC and Natural England at least four months prior to any (pre-construction) works commencing.

12.12.3 In addition, as detailed in Section 12.6, based on the experience of the GGOWF construction, the beach profile will be monitored at the location of the reception pit to identify any potential slumping of shingle following construction to identify any need for future action.
12.13 **Summary**

12.13.1 This Chapter of the ES has provided a characterisation of the existing marine and intertidal environment based on both existing and site specific survey data, which has established that communities present are indicative of the region and occur over broad extents throughout the Outer Thames Estuary and southern North Sea. Species of conservation importance (such as *S. spinulosa*, have been recorded within the study area, although none were found in their most sensitive and important form (biogenic reef).

12.13.2 **Table 12.7** provides a summary of the predicted impact on marine and intertidal ecology. The impacts represent the maximum potential adverse impact as a result of having assessed the worst case (development) scenario for each receptor. Therefore, the predictions made would not be worse (more adverse) should any other development scenario (in line with those provided in Chapter 5), to that assessed within this Chapter, be taken forward in the final scheme design.

**Table 12.7 Summary of impacts**

<table>
<thead>
<tr>
<th>Description of Impact</th>
<th>Impact</th>
<th>Mitigation Measures</th>
<th>Residual impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Phase – Intertidal</td>
<td>Direct impact due to physical disturbance</td>
<td>Negligible</td>
<td>Minimise footprint of directional drilling reception pit. Excavated shingle layers will be segregated and stored separately and replaced in the same sequence.</td>
</tr>
<tr>
<td>Construction Phase – Subtidal</td>
<td>Direct impact due to physical disturbance on subtidal ecology</td>
<td>Negligible</td>
<td>Micrositing of equipment / cables if any areas of <em>S. spinulosa</em> reefs are identified.</td>
</tr>
<tr>
<td></td>
<td>Direct impact due to loss of habitat</td>
<td>Negligible</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Indirect impact due to increased</td>
<td>Negligible</td>
<td>N/A</td>
</tr>
<tr>
<td>Description of Impact</td>
<td>Impact</td>
<td>Mitigation Measures</td>
<td>Residual impact</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------</td>
<td>---------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>suspended sediments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect impact due to re-mobilisation of contaminated sediments</td>
<td>Negligible</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Operation Phase – Intertidal**

| Direct impacts due to maintenance activities | Negligible | N/A | N/A |
| Indirect impacts due to changes in current regime | No impact | N/A | N/A |

**Operation Phase – Subtidal**

| Direct impacts due to maintenance activities | Negligible Minor adverse *(S.spinulos a)* | N/A | Negligible Minor adverse |
| Direct impacts through habitat alteration | Negligible | N/A | N/A |
| Indirect impacts due to changes in current regime | Negligible | N/A | N/A |
| Indirect impacts through alteration to existing human activity | Negligible | N/A | N/A |

**Decommissioning – Intertidal**

<p>| Impact on ecology | Negligible | N/A | N/A |</p>
<table>
<thead>
<tr>
<th>Description of Impact</th>
<th>Impact</th>
<th>Mitigation Measures</th>
<th>Residual impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decommissioning – Subtidal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct impact due to physical disturbance on subtidal ecology</td>
<td>Negligible</td>
<td>Jack up barge movements kept to a minimum. Micrositing of equipment if any areas of S. spinulosa reefs are identified.</td>
<td>Negligible</td>
</tr>
<tr>
<td>Direct impact due to loss of habitat</td>
<td>Minor adverse</td>
<td>Should surveys show that benthic assemblages have developed to such an extent that the decommissioning process will result in unacceptable levels of impact, then GWFL will explore the potential for a Decommissioning Plan that allows some structures to remain on the seabed.</td>
<td>Negligible</td>
</tr>
<tr>
<td>Indirect impact due to increased suspended sediments</td>
<td>Negligible</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Indirect impact due to re-mobilisation of contaminated sediments</td>
<td>Negligible</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

12.13.3 No significant impacts are anticipated over the construction, operation or decommissioning phases of GWF either alone or cumulatively with other activity, plans or projects on the intertidal or subtidal environment. The conclusions drawn are in line with those predicted for the adjacent GGOWF project, as would be expected given the similar ecological characteristics and proposed project envelopes that were assessed.

12.13.4 GWFL will undertake pre-construction surveys to establish for the presence of any Annex I habitat (such as S.spinulosa reef) and will also monitor the beach profile at the reception pit locations. The requirement for any further monitoring will be established with the regulator and relevant stakeholders prior to construction.
12.14 References


Centre for Environment, Fisheries and Aquaculture Science (Cefas) (2011). Draft guidelines for data acquisition to support marine environmental assessments for offshore renewable energy projects


East Anglia Offshore Wind (2010). East Anglia ONE offshore wind farm. EIA Scoping Report. Supplementary information on connection to the onshore electricity network

The Ecology Consultancy (2010). Sizewell ecology survey report for GWFL


Marine Aggregate Levy Sustainability Fund (MALSF) (2009). Outer Thames Estuary Regional Environmental Characterisation


Posford Haskoning (2003). Felixstowe South Reconfiguration Environmental Statement; Subtidal Marine Communities.


Royal Haskoning (2009). Galloper Wind Farm Phase 1 Habitat Survey


SSER and RWE NRL (2010). Galloper Wind Farm Project Scoping Study. Client: SSE Renewable Developments UK Ltd and RWE Npower Renewable Ltd


Titan (2002). Gunfleet Offshore Wind Farm benthic survey
