The Sizewell C Project

6.3 Volume 2 Main Development Site

Chapter 22 Marine Ecology and Fisheries

Appendix 22K - Sizewell C: Site Characterisation for the Disposal of Material Associated with Drilling and Dredging

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Sizewell C: Site characterisation for the disposal of material associated with drilling and dredging

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Please note that the red line boundary was amended after this document was finalised, therefore figures in this document do not reflect the boundaries in respect of which development consent has been sought in this application. However, amendments to the red line boundary does not have any impact on the findings set out in this document and all other information remains correct.

Executive summary

EDF Energy proposes to construct and operate a new nuclear power station (new nuclear build, or NNB) immediately to the north of the existing Sizewell B station on the Suffolk coast. Under the Planning Act 2008, this development, as with other nationally significant infrastructure projects, requires a Development Consent Order (including, in the case of conservation areas, a Habitats Regulations Assessment) to be granted by the UK Government's Planning Inspectorate. The marine aspects of the development will also require regulatory permits and Marine Licences for, amongst other activities, cooling water discharges and activities that disturb the seabed. In the UK dredging and disposal is a licensable activity managed by the Marine Management Organisation (MMO) under the Marine and Coastal Access Act 2009. Disposal activities must reference a designated disposal site.

The site of the proposed Sizewell C NNB and associated marine works is located on the Suffolk coast approximately 40km north of the major port of Harwich. The construction of the marine infrastructure necessary to support the cooling water intakes and outfalls, combined drainage outfall and fish recovery and return structures requires capital dredging to remove surface material. Dredging would also be required for the beach landing facility (BLF) in the shallow subtidal to allow access by barges. Dredging for the BLF would be via plough dredging. Plough dredging pushes and agitates the sediment, which is redistributed by tidal processes, spoil is not extracted and hence plough dredging does not require a disposal site or disposal licence. Plough dredging is not considered further as part of the disposal site assessment, with the exception of the in-combination plume effects with other dredge activities.

In the case of the cooling water intakes and outfalls, dredging would be required to the depth to fit the structures to the bedrock. Vertical tunnels would be drilled in the wet to connect the cooling water intakes and outfalls with the subterranean cooling water tunnels. Local disposal of dredge spoil and drill arisings is considered to be the most practical option because it would keep the sediment within the same sediment system and negate the need to load sediment onto a barge and transit to another location. It is expected that dredging and disposal will be undertaken with a cutter suction dredger disposing of sediment at the surface via a pipe extended up to 500m from the dredge site. Dredging for the offshore infrastructure would be part of a coordinated programme of dredging.

EDF Energy is seeking to have a new disposal site designated within the footprint of Sizewell C NNB to enable the single capital dredge activities with disposal at sea of the overburden material and drill arisings from the installation of each of the marine infrastructures. This report provides the site characterisation for the proposed new disposal site as required by Marine Management Organisation to allow them to consider designation of a new offshore disposal site. This characterisation refers to and utilises the Sizewell Environmental Statement (ES) and the technical reports supporting the ES. The purpose of this report is to provide all the relevant information for the disposal site characterisation in a single report and not to reassess or supersede any part of the ES. The potential effects on designated conservation sites are assessed in the Habitat Regulation Assessment (HRA) for the DCO application and hence separate assessment in this report is not considered necessary.

The assessment of the potential impacts of the use of the disposal site has been carried out for a range of receptors. Negligible effects are predicted on coastal processes and only minor adverse effects are anticipated to sediment and water quality, marine ecology (plankton, benthic ecology, fish ecology) and for fisheries. Effects are negligible for marine mammals. Effects are predicted to be short-lived and not significant relative to natural variation. Finally, no adverse effects are predicted for designated conservation sites.

1 Background

EDF Energy proposes to construct and operate a new nuclear power station (new nuclear build, or NNB) immediately to the north of the existing Sizewell B station on the Suffolk coast. Under the Planning Act 2008, this development, as with other nationally significant infrastructure projects, requires a Development Consent Order (including, in the case of conservation areas, a Habitats Regulations Assessment) to be granted by the UK Government's Planning Inspectorate. The marine aspects of the development will also require regulatory permits or deemed Marine Licences for, amongst other activities, cooling water discharges and activities that disturb the seabed.

In the UK dredging and disposal is a licensable activity and managed by the Marine Management Organisation (MMO) under the Marine and Coastal Access Act 2009. The UK is also a contracting party to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention and more recent iteration London Protocol) as well as the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR). Both the London Protocol/London Convention and OSPAR require member states to manage dredge disposal activities and report disposal activity.

Disposal sites in the UK are not individually licenced, however disposal activities must be linked to a registered disposal site, which are designated by the MMO in England. Disposals to designated disposal sites are managed by the MMO to ensure the type of material and total volume of licenced disposal is appropriate for specific disposal sites. The designation of a disposal site provides a formal process to agree with the MMO the bounding coordinates of the site, consider potential alternatives and assess the potential impacts of use of the site. It should be noted that the designation of a disposal site does not licence subsequent use of the site. Disposal activities are licenced under a Marine Licence (or deemed Marine Licence in the case of a DCO) which must reference a designated disposal site.

Principles for disposal site selection and assessment are set out in the OSPAR dredging guideline (OSPAR, 2014). The assessment herein follows these guidelines and aims to provide the MMO with all the information required to consider the proposed new disposal site at Sizewell C.

In common with similar disposal site designation reports (BEEMS Technical Report TR340; Galloper Wind Farm Limited 2015, East Anglia One Limited 2017), this report is structured into four main sections detailing:

- The need for a new disposal site (Section 2)
- The characteristics of the material to be disposed (Section 3)
- The disposal site characteristics (Section 4) and;
- The assessment of potential effects (Section 5).

This report refers to and utilises the assessments in the Sizewell C Environmental Statement (ES) and the technical reports supporting the Environmental Statement (EDF Energy, 2020a). Further detail of the assessment methods and results can be found in the reports referenced herein. The purpose of this report is to provide all the relevant information for the disposal site characterisation in a single report and not to reassess or supersede any part of the ES.

2 The need for a new disposal site

The site of the proposed Sizewell C NNB and associated marine works is located on the Suffolk coast approximately 40km north of the major port of Harwich. The construction of the marine infrastructure necessary to support the cooling water intakes and outfalls, combined drainage outfall (CDO) and fish recovery and return (FRR) structures requires capital dredging to remove surface material and dredging or drilling to the depth required to fit the structures to the seabed and associated tunnelling. Details of the construction phase activities are provided in Chapter 4 Volume 2 of the Environmental Statement submitted for DCO application. The specific timeline is to be confirmed but the indicative earliest start date is assumed to be 2022, with peak construction occurring in 2028. The primary dredge activities are anticipated to occur at approximately this point.

It is expected that dredging and disposal will be a single capital dredge event prior to the installation of infrastructure. Dredging would be undertaken with a cutter suction dredger disposing of sediment at the surface via a pipe extended up to 500m from the dredge site.

There are no currently open existing registered disposal sites in the local area (i.e. within a reasonable transit distance). Local disposal is therefore considered to be the most practical option because it would keep the sediment within the same sediment system (noted as a priority in the OSPAR (2014) guidelines) and negate the need to load sediment onto a barge and transit to another location.

The disposal site for the Galloper offshore wind farm (TH057) was located in the same area as the proposed Sizewell C disposal site. It is understood that the TH057 site is now closed due to completion of the works and expiration of the licences associated with this disposal site (MLA/2015/00340 and MLA/2015/00341) (MMO, personal communication).

The coordinates of the proposed disposal site are given in Table 1 and shown on Figure 1. The site has been proposed as a single polygon encompassing the maximum extent of possible disposal (i.e. 500m distant from each dredge site). The site is 4km by 2km in size. This area has been proposed for simplicity and practicality and to fit with the assessment scale (i.e. it would not be practical to designate individual sites for each dredging activity as they would overlap and the assessments for each would draw on the same information).

Table 1: Coordinates for the proposed new disposal size (BNG and WGS1984)

Point	Easting (m)	Northing (m)	Latitude	Longitude
1	647 745	264 840	52.2259	1.6261
2	651 653	264 840	52.2242	1.6832
3	651 653	262 820	52.2060	1.6817
4	647 745	262 820	52.2078	1.6246

2.1 Predicted sources, volumes and fate of material for disposal

2.1.1 Sources of material for disposal

Material for disposal will be derived from two activities; dredging and drilling. Dredging is required at the CDO site, cooling water intake and outfall sites and the two FRR sites. The foundations for the infrastructure will be installed into bedrock, dredging is necessary to remove surficial sediment and part of the bedrock at each location to establish the foundations. Although the sediment thickness is likely to vary between the dredge sites a worst-case assumption of 6m of sediment has been allowed for in the calculations of dredge volumes (Table 2).

Drilling is required for the vertical connecting shafts for the cooling water intakes and outfall locations. The shafts are expected to be 15m deep with a diameter of 8m. The volumes calculated in Table 2 are precautionary and assume a full 15m of drilling, however it is expected that up to 6m will be surficial sediment removed via dredging.

Dredging would also be required for the beach landing facility (BLF) in the shallow subtidal to allow access by barges. Dredging for the BLF would be via plough dredging. Spoil is not extracted by plough dredging and hence does not require a disposal site or disposal licence. Plough dredging is not considered further.

Table 2: Expected dredging activities an associated disposal volume

Component	Dredge/drilling method and proposed disposal route	Dredge volume and surface area	Duration and frequency	Sediment characteristics	Assessed further in the ES
Combined drainage outfall (CDO).	Cutter suction dredger with local disposal via a down tide pipe.	**1,845m^3** 1,320m^2	Single dredge event anticipated for the CDO head. Dredging expected to take 9.5 hours.	95% fine to medium sand (63µm-210µm). 5% fines (<63µm).	Yes
Cooling water system (CWS) intakes.	Cutter suction dredger with local disposal via a down tide pipe.	**69,600m^3** 20,150m^2	Single dredge event anticipated for each of the four CWS intake heads. Dredging expected to take 34 hours in total (8.5 hours per head).	75% fine to medium sand (63µm-210µm). 20% medium to coarse sand (210µm-420µm). 5% fines (<63µm).	Yes
	Drilling with arisings released at drill site.	**3,016m^3** 201m^2	Continuous drilling for all four intake heads lasting 120 hours in total (30 hours per head).	50% of drill arisings expected to form spoil heap. 50% expected to be fines (<63µm).	The SSC plume would be indiscernible above background conditions – Not assessed. A localised spoil heap would form (primarily in the dredge footprint), wider sedimentation rates would be minimal. The impact of the spoil heap is assessed.
Cooling water system (CWS) outfalls.	Cutter suction dredger with local disposal via a down tide pipe.	**23,500m^3** 7,442m^2	Single dredge event anticipated for each of the two CWS outfall heads. Dredging expected to take	60% fine to medium sand (63µm-210µm).	Yes

			14 hours in total (7 hours per head).	10% medium to coarse sand (210µm-420µm). 30% fines (<63µm).	
	Drilling with arisings released at drill site.	**1,908m³** 127m²	Continuous drilling for both outfall heads lasting 60 hours in total (30 hours per head).	Same as drilling for CWS intakes.	As for drilling for CWS intakes.
Fish recovery and return (FRR) outfalls.	Cutter suction dredger with local disposal via a down tide pipe.	**3,690m³** 2,640m²	Single dredge event anticipated for each of the two FRR outfall heads. Dredging expected to take 19 hours in total (9.5 hours per head).	Same as dredging for CDO.	Yes
Total		**103,559 m³**			

2.1.2 Fate of disposed material

Detailed 3D sediment dispersion modelling has been carried out to support the assessments required for the Sizewell ES (BEEMS Technical Report TR480). The modelling has assessed two scenarios: dredging of the intake and outfall structures of the CWS and dredging of the FRR outfalls and the CDO separately.

Two disposal locations were modelled, one for each scenario (each 500m south east of the dredging point). Both modelled disposal locations are within the proposed disposal site. Further dredging is required for the BLF, however while assessed in the modelling studies, this will be via plough dredging and hence does not require a disposal site and is not considered further as part of the disposal site assessment herein. Dredging and disposal of each location is assessed individually as the construction schedule does not propose consecutive dredging for the various offshore infrastructure within the site (EDF Energy, 2020a). The largest plumes are described within this report to illustrate the worst-case scenario.

The modelling methods are reported in detail in the sediment dispersion modelling technical report (BEEMS Technical Report TR480). In summary, a Delft3D hydrodynamic model was used to simulate dispersion of sediment arising from the dredging/drilling activity and disposal. The modelling grid horizontal resolution varies from approximately 25m x 25m at the dredging locations to 100m x 100m up to 1km distant.

The cooling water headworks would be located seaward of the Sizewell-Dunwich Bank and would be affixed to the bedrock thereby requiring removal of surficial sediments. To ensure a conservative assessment of dredge volumes, the surface sediment layer is assumed to be 6m deep. Geological interpretation of the overlying sediment indicates sediment thickness at the location of the northern intakes (Unit 2) and cooling water outfalls varies between tens of centimetres to more than two metres in these areas. As such, volume estimates applied in plume modelling are precautionary. The southern intakes associated with Unit 1 would be positioned on exposed Coralline Crag deposits, with no or minimal overlying sediment. As such, dredge volume estimates applied in plume modelling are highly precautionary. The dredging of surficial sediments would be expected to take approximately 8.5 hours to complete at each CWS intake structure (with 9 cycles of 30 minutes of dredging, followed by a 30-minute interval for repositioning) and 7 hours at each outfall head (with 9 cycles of 20 minutes of dredging, followed by a 30-minute interval for repositioning). Drilling is assumed to take approximately 180 hours to drill through the 13m of Coralline Crag bedrock to connect the main cooling water tunnels.

The CDO and FRR headworks are located in the inshore environment. These small structures would be partially buried in the surficial sediment. For each FRR and the CDO the dredge would take approximately

9.5 hours to complete (with 12 cycles of 19 minutes of dredging, followed by a 30-minute interval for repositioning).

The tidal currents in the region are dominated by the semi diurnal constituents M2 and S2 and are highly rectilinear (i.e., north to south) and typical spring tidal velocities near Sizewell are 1.2m/s (BEEMS Technical Report TR311, available as Appendix 20.A of Volume 2 of the Environmental Statement). As can be anticipated from the tidal conditions, the modelling results show material is moved north - south from the point of disposal.

- Modelling results for the CWS

During the dredging of the cooling water intake and outfall structures and associated local disposal of sediments, an elongate area extending approximately 13km to the north, 22km to the south and one kilometre east-west is affected by transient increases in SSC of more than 100 mg/l above background transported by the tide (BEEMS Technical Report TR480). Suspended sediment conditions are expected to return to background within several days, and no area is affected by increases of more than 50mg/l of SSC for more than 6 hours.

Deposition close to the disposal site could reach more than 1,000mm (1m) in the immediate vicinity of disposal (i.e. within 0.5ha). The deposition thickness reduces with distance from the disposal site with typical values of 10mm (maximum 50mzm) at distances of more than 1km (Figure 2). The suspended sediment and deposition model show no interaction with the shoreline.

The drilling activity at the cooling water structures is expected to produce a very diffuse suspended sediment plume of approximately 5mg/l above background. Deposited material from drilling is expected a accumulate close to the deposit location extending up to 60m around the disposal point, thickness of the deposits from drilling are expected to be between 0.05m and 0.5m and reduce to less than 0.2mm beyond the immediate area around disposal.

- Modelling results for the FRR and CDO

During dredging of the FRR an CDO locations, an elongate north to south suspended sediment plume is expected as with the cooling water intakes and outfalls. In the inshore environment, suspended sediment concentrations of more than 100mg/l are limited to within 6.5km north and 5.5km south of the disposal point. As with the cooling water structures the plume from the FRR and CDO dredging and disposal is short lived, and no area is affected by increases of more than 50mg/l of SSC for more than 6 hours at a time. Some of the suspended sediment is predicted to interact with the coastline with sediments mixing with beach sediments. Deposition is highest close to the disposal point with values up to 20mm modelled. Deposition up to 2mm in localised patches up to 7km north and 8km south is predicted (Figure 3).

2.2 Consideration of alternative uses

In line with the OSPAR Convention and the London Protocol it is the UK Government's policy that no waste should be disposed at sea if there is a safe and practicable alternative. If no alternative uses for the dredged material can be found then, provided the dredged material is suitable for disposal at sea, the MMO may grant a licence for its disposal at sea at designated disposal sites.

The waste framework directive (2008/98/EC) details the waste hierarchy which comprises (in order of priority), prevention, re-use, recycle, other recovery, and disposal as the options of detailing with waste.

Prevention: dredging is required for safe installation of the infrastructure. While some dredging utilises plough dredging techniques (negating the need for disposal), this is not a practical option for the infrastructure foundations as dredge areas are in deep water and required to the depth of the bedrock with a level of precision to prevent infilling. Prevention is not considered possible.

Re-use/recycle: In theory sand dredged could be utilised in beach nourishment schemes or recycled in construction, however this would result in removal of the sediment from the Greater Sizewell Bay region. Maintaining the sediment within the same system is considered a priority to reduce impacts on coastal processes. Therefore, re-using or recycling the material at a different location is not considered feasible as it could create new impacts through removal of the sediment from the wider system.

Maintaining the sediment within the Greater Sizewell Bay is considered the best available option and hence designation of new disposal site is proposed.

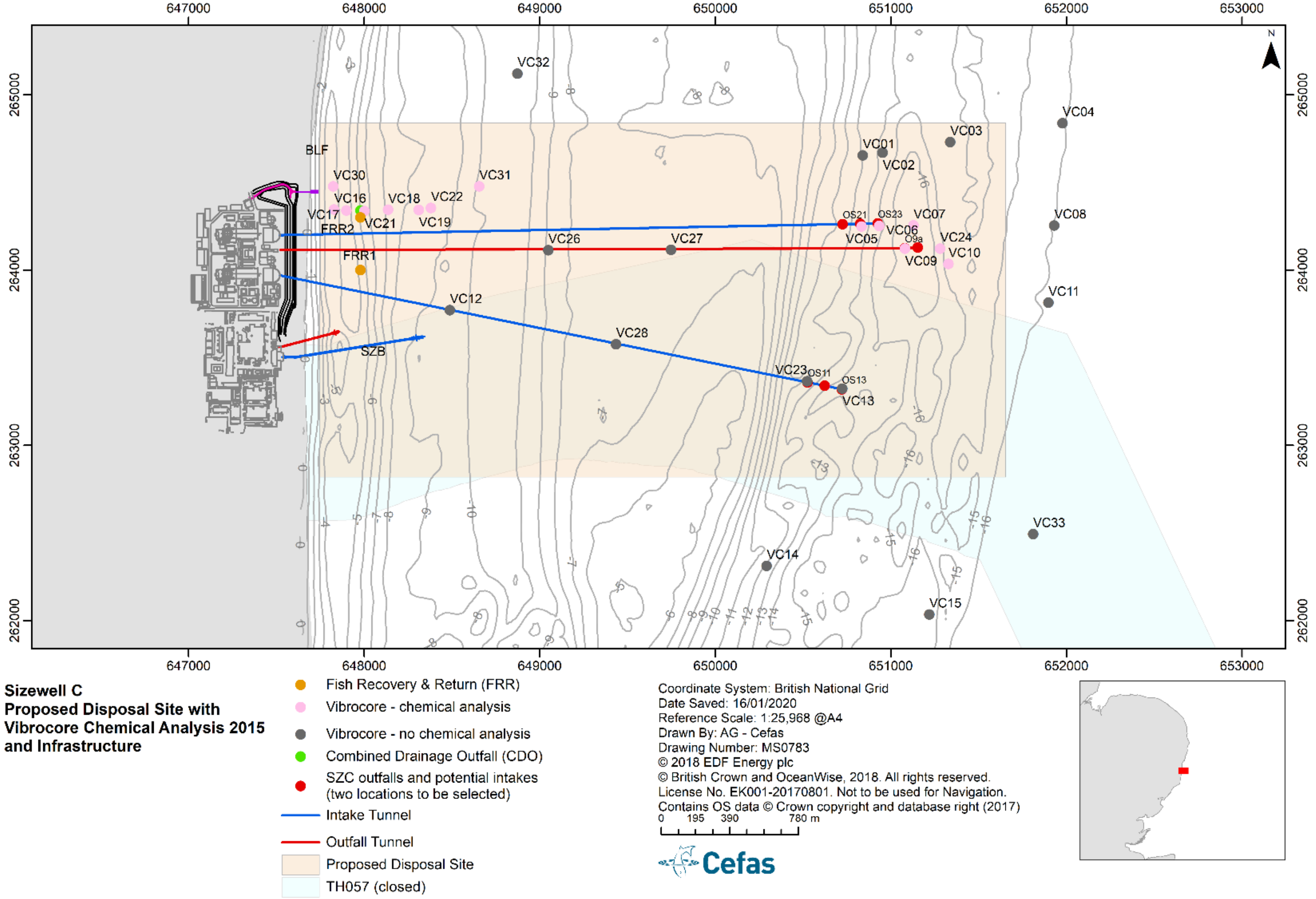

Figure 1: Proposed disposal site location with Sizewell infrastructure and sediment core sampling (2015).

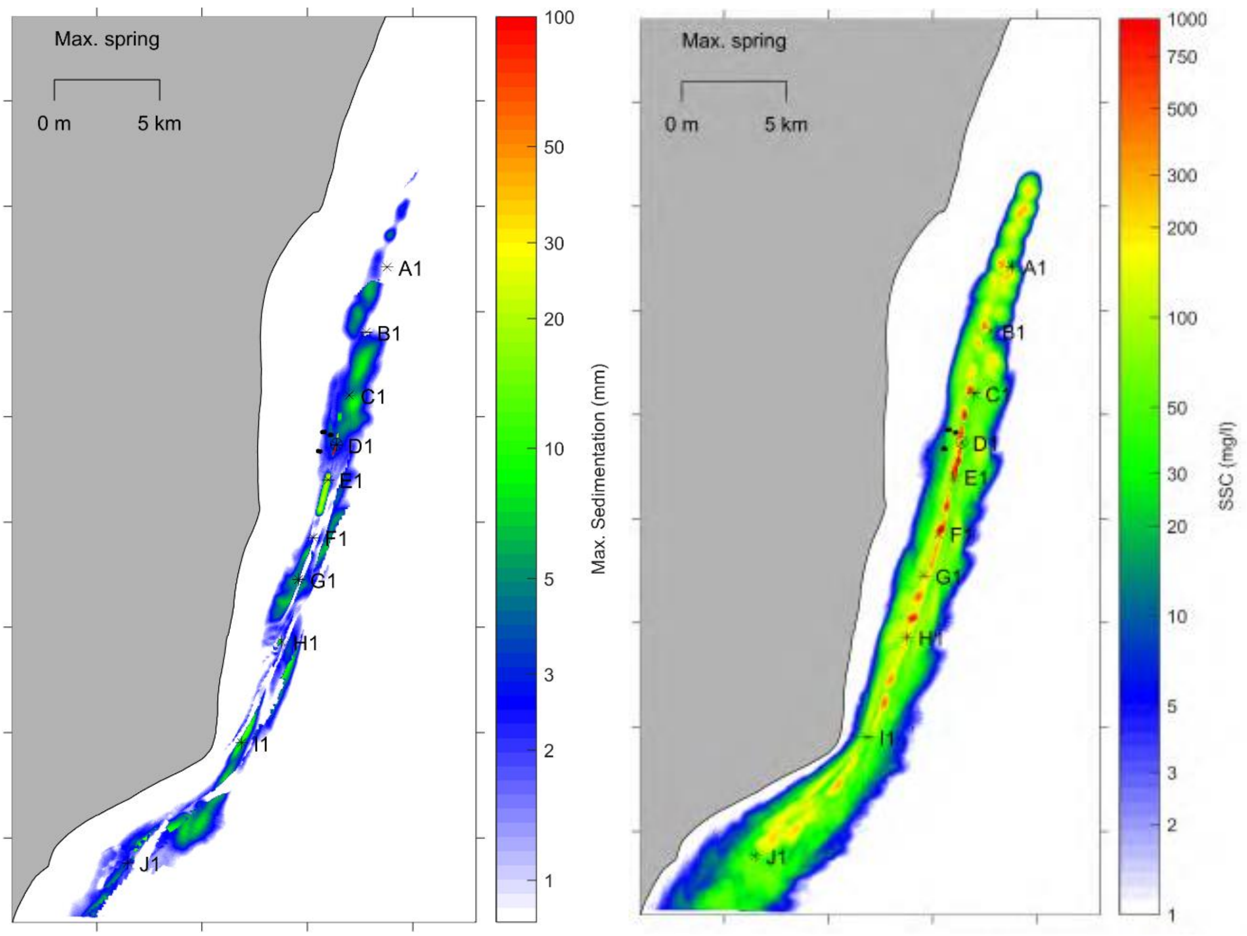

Figure 2: Plume model extract; (Left) location maximum sedimentation associated with dredging at Intake I4a. (Right) maximum depth average SSC associated with dredging at Intake I4a. Maximum refers to the grid cell maximum throughout the model simulation, plots do not present instantaneous plumes.

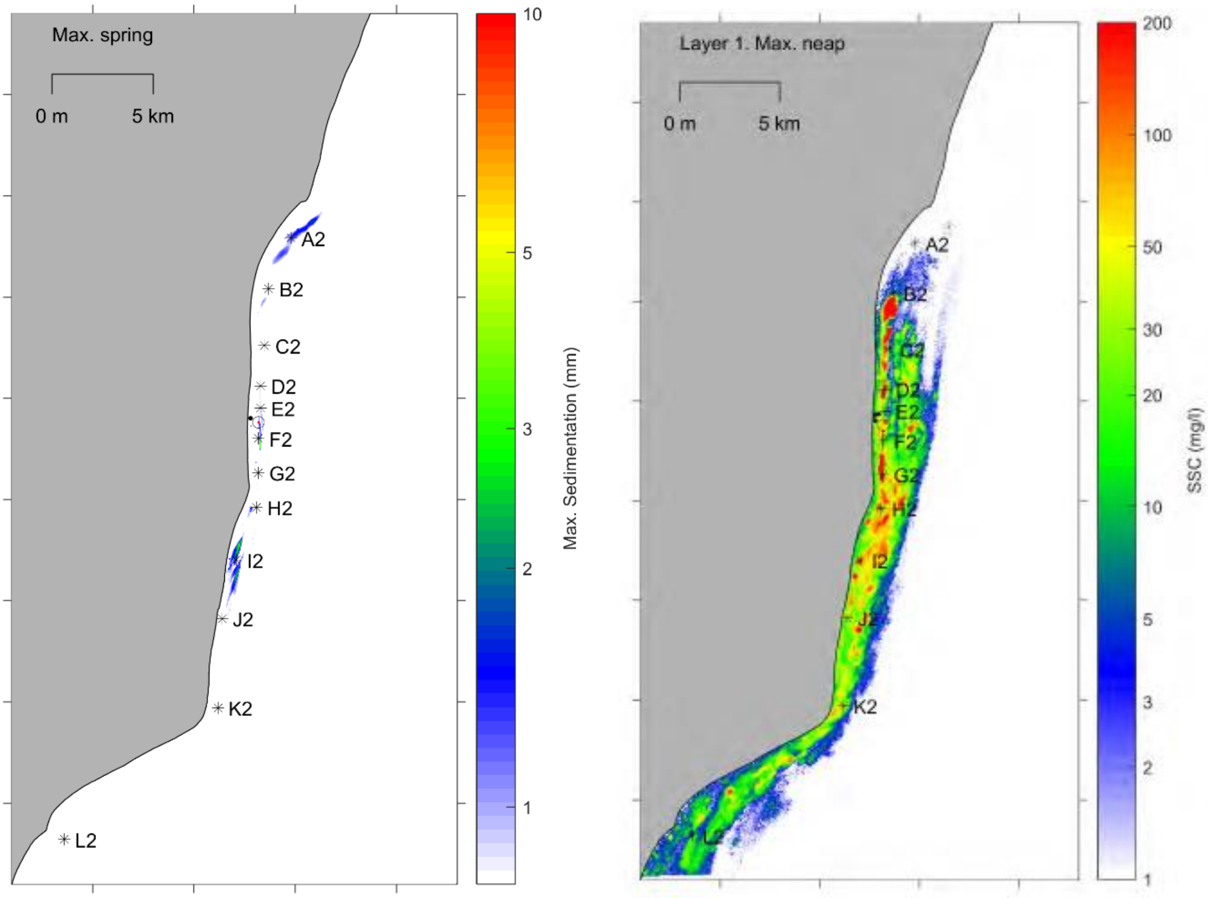

Figure 3: Plume model extract; (Left) location maximum sedimentation associated with dredging at FRR1. (Right) maximum depth average SSC associated with dredging at FRR1 (note the different scale compare to Figure 2). Maximum refers to the grid cell maximum throughout the model simulation, plots do not present instantaneous plumes.

3 Characteristics of material to be disposed

The chemical and physical composition of dredged material to be disposed as sea must be deemed acceptable by the MMO before disposal operations. Typically, sediment samples are required following the MMOs guidance[1] which adheres to the OSPAR guidelines (OSPAR, 2014) and the London Protocol guidance (IMO, 2005; IMO 2013). The purpose of this section is to demonstrate that the material to be dredge is likely to be acceptable for disposal at sea. Samples of dredge material are typically required within 3 to 5 years prior to the dredging event(s). The construction phase activities are detailed in Chapter 4 Volume 2 of the Environmental Statement. The indicative earliest start date is assumed to be 2022, with peak construction occurring in 2028. As the timing of dredging is not confirmed at present the final assessment of the acceptability for disposal at sea will be determined with the dredging licence (Marine Licence) which is expected to carry a condition requiring the MMO to approve dredging activities. Further sediment samples are anticipated to be required to enable a contemporary assessment at the appropriate time relative to dredging activities.

3.1 Physical characteristics

Core sampling across the Sizewell development area was carried out in 2015, the results of which are reported in BEEMS Technical Report TR305, available as Appendix 21D, Volume 2 of the Environmental Statement. Sampling locations are shown on Figure 1. It should be noted that this sampling was conducted before specific dredge locations were known and therefore alignment of samples was based on the requirements at the time of planning. Fourteen core stations were sampled with vertical sub-samples at approximately 1m intervals. Particle size samples were analysed by Fugro (it is acknowledged that Fugro are not an MMO certified laboratory for determination of particle size for dredge material; these data are provided as an indication of the physical composition not for final determination of the acceptability of the material to be disposed at sea).

Particle size analysis (PSA) shows that the majority of the samples consisted of sandy material with low organic carbon content (0.08 – 0.1 OC% inshore and 0.58 – 0.82% further offshore) (BEEMS Technical Report TR305). The samples closest to the cooling water infrastructure dredging location (VC05, VC06, and VC09), showed that the surficial sediments are mostly sand (>74%) with small proportions of silt/clay, sub-bottom sediments show variability with higher levels of silt/clay, but not exceeding 50%. The sample closest to the FRR and CDO (VC21) shows surficial sediments are sand, but with high vertical variability with fine material occurring in the sub-bottom cores (Table 3).

[1] https://www.gov.uk/guidance/marine-licensing-sediment-analysis-and-sample-plans

Table 3: Particle size summary from vibrocore samples close to the dredging location (sampling from 2015).

Sample	Depth (m)	Silt/Clay (%)	Sand (%)
VC05	0.00 - 0.20	26	74
VC05	1.00 - 1.20	6.69	93.31
VC05	2.00 - 2.20	29.9	70.1
VC05	3.00 - 3.20	49.1	50.9
VC06	0.00 - 0.20	25.5	74.5
VC06	1.00 - 1.20	21.9	78.1
VC06	2.00 - 2.20	4.71	95.29
VC09	0.00 - 0.20	10.6	89.4
VC09	1.00 - 1.20	36.1	63.9
VC09	2.00 - 2.20	1.62	98.38
VC21	0.00 - 0.20	<0.01	>99.99
VC21	1.00 - 1.20	21.5	78.5
VC21	2.00 - 2.20	82.8	17.2
VC21	3.00 - 3.20	22	78

3.2 Chemical characteristics

As part of the 2015 geotechnical survey, vibrocores were taken across the Sizewell site corresponding to areas where proposed infrastructure installations would occur (Figure 1). A detailed report and summary tables of the results can be found in BEEMS Technical Report TR305 Samples were analysed for chemical and heavy metal contaminants including:

- Heavy metals and insecticides – Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Zinc, DDT and Dieldrin. (Analysed by National Laboratory Service following aqua regia digest);
- Organotin and Particle size – Monobutyl-tin (MBT), Dibutyl-tin (DBT), Tributyl-tin (TBT). (Analysed by Fugro (FAOL));
- Organic and chlorinated compounds – Polyaromatic Hydrocarbons (PAHs), Total Hydrocarbon Content (THC) and Polychlorinated biphenyls (PCBs). (Analysed by Cefas); and
- Radionuclides (five core samples). (Analysed by Cefas).

A discussion of the chemical characteristics of the wider site (i.e. the proposed disposal area) is presented in section 4. This section details the chemical characteristics of the material likely to be dredged. As described in section 3 a detailed characterisation of the dredge material is anticipated prior to the dredging works, and the description herein is provided to facilitate designation of the disposal site only. It is acknowledged that Fugro and National Laboratory Services were not an MMO certified laboratory for dredge material at the time of the analysis in 2015; these data are discussed as an indication of the chemical composition and not for final determination of the acceptability of the material for disposal at sea.

Disposal of drill arisings and dredge spoil is regulated in England by the MMO. There are no statutory thresholds to assess the quality of marine sediment in the UK. Cefas Action Levels are used as part of a ‘weight of evidence’ approach to assessing the contaminant loading in dredged material and its suitability for disposal to sea. The general guidance for Cefas Action Levels is as follows:

- Below Cefas Action Level 1 - Contaminant levels in dredged material are generally considered of no environmental concern.
- Between Cefas Action Level 1 and Cefas Action Level 2 - Contaminant levels in dredged material require further consideration before a licensing decision can be made.

- Above Cefas Action Level 2 - Contaminant levels in dredged material is generally considered unsuitable for sea disposal.

Material to be drilled is considered to be undisturbed geological material and hence would not pose a risk of anthropogenic contamination. It is anticipated that this material would be acceptable for disposal at sea without detailed chemical characterisation following the OSPAR guidelines (OSPAR, 2014).

Radionuclide sampling show that concentrations in marine sediments at Sizewell are low (with many values below the limit of detection) and consistent with routine local radionuclide monitoring by the Environment Agency.

The sediment samples collected around the dredging locations (cores VC05, VC06, VC09 and VC21 are considered the most representative) show that organotin and some heavy metals were below Cefas Action Level 1 and pose no environmental concern. Arsenic, nickel and chromium marginally exceeded Cefas Action Level 1 in select samples but were not approaching or close to approaching Action Level 2. The full results and summary tables are provided in BEEMS Technical Report TR305.

PBCs were below detection levels in most samples and, where detected, were considerably below the Action Level 1 levels of 0.02 mg/kg for summed PCBs.

Polyaromatic hydrocarbons (PAH) and total hydrocarbon content (THC) exceeded Cefas Action Level 1 for some determinants (no Cefas Action Level 2 exists for hydrocarbons). Elevated levels above the probable effect levels (PEL) for dimethyl naphthalenes occurred in eleven samples. All other determinants were below PEL limits. A further method to examine PAHs in marine sediments involves assessing levels of grouped PAHs based on their origin and effects characteristics, to published effects ranges. Hydrocarbons can be grouped into low molecular weight (LMW) and high molecular weight (HMW) compounds[2]; LWM are typically from oil (termed 'petrogenic') sources, are highly volatile so evaporate quickly, have high solubility and are easily absorbed across cell membranes and are acutely toxic and carcinogenic. HMW are typically derived from 'pyrolytic' sources (e.g. burning of fossil fuels) they are more pervasive with low volatility, are often bound to particulates in air or sediment and are more persistent in the environment. Effects ranges typically used for assessment include the 'effect range low' (ERL) and the effects range medium (ERM). Effects on biota at concentrations below the ERL are rarely observed however at levels above the ERM effects are generally or always observed. The ERL and ERM values for summer LWM and HMW PAHs are given in (Buchman, 2008) as; 552ng/g (ERL) and 3,160ng/g (ERM) for LWM and 1,700ng/g (ERL) and 9,600 (ERM) for HWM. All values for the sediment samples were below the relative ERM values and all except two samples were below the ERM values. Samples VC10 (surface) and VC24 (surface) marginally exceed the ERL for LWM PAHs (levels of 725ng/g and 793ng/g respectively), however these exceedances are marginal and the ERL should be considered a low point on a continuum of possible effects, furthermore these two locations represent the highest proportions of fines in the surface sediments and therefore can be expected to adsorb relatively higher levels of organic compounds compared to coarser sediments

The interpretation of the 2015 samples indicates that the sediment to be dredged should be considered acceptable for disposal at sea.

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[2] Low Molecular Weight (LMW: naphthalene, methyl naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene) and High Molecular Weight (HMW: fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[a]pyrene, dibenz[a,h]anthracene)

4 Characteristics of the disposal site

4.1 Physical and chemical

The geomorphological environment of the Greater Sizewell Bay area (including the proposed disposal site area) is described in detail in BEEMS Technical Report TR311, available as Appendix 20A of Volume 2 of the Environmental Statement. In the area covered by the proposed disposal site water depth varies from approximately -2m ODN to -16m ODN. The area is characterised by predominantly sandy subtidal sediment with the Sizewell – Dunwich Bank; a single sedimentary feature 3.5km to 4km from shore. Its higher north and south ends are often referred to as Dunwich Bank (-4m to -5m elevation) and Sizewell Bank (- 3 to - 5m elevation), are joined by a lower elevation saddle (-7m elevation). Coralline Crag ridges outcrop sub-tidally in small patches of the subtidal environment (Figure 4).

The tidal currents in the region are dominated by semi diurnal constituents and are highly rectilinear (i.e., North – South). Typical spring tidal velocities near Sizewell are 1.2m/s. The tidal range increases from North to South across the region with spring tides from 1.9m at Lowestoft, 2.2m at Sizewell and to 3.5m at Felixstowe. Water movement is dominated by tidal currents that flow south for most of the rising (flood) tide (1.14m/s (peak) seaward of Sizewell Bank) and flow north for most of the falling (ebb) tide (1.08m/s). The strong tides and generally shallow bathymetry combine so that the water column is thermally well mixed throughout the year. Further details on the tidal currents are described in BEEMS Technical Report TR311.

The offshore wave climate at Sizewell is monitored with a Datawell Directional Wave Recorder buoy (DWR), which is deployed offshore (approx. 4km) from Sizewell Bank in 18m depth of water. The main features of the wave state are; The largest fetch is towards the north (up to 3,000km), with the largest waves propagating from this direction as would be expected. South-easterly waves are mostly generated by winds from the south-southeast sector and have a much shorter fetch (up to 150km) and are therefore typically smaller than waves from the north; The offshore wave climate is bidirectional with the most frequent waves propagating from north-east (23.16%), south (20.25%) and south-east (15.13%) i.e., north-east and south-south-east bidirectionality. Further details on the wave climate are described in BEEMS Technical Report TR311.

Measurement of suspended sediment levels are detailed in BEEMS Technical Report TR311. Observations from a minilander deployed approximately 0.5km off the Sizewell C station show daily maximum levels of suspended sediment at 1m above the seabed ranging from 266mg/l to 459mg/l with higher levels (up to 609mg/l) observed at 0.3m above the seabed. Calibrated optical backscatter sensors were mounted on two seabed landers deployed seaward of the Sizewell-Dunwich Bank at the proposed cooling water intake head locations between November 2018 and February 2019. The mean SSC at 1.4m above the seabed was 452mg/l and 513mg/l at the northern and southerly positions, respectively. In both locations maximum SSC exceeded 2,000mg/l (BEEMS Technical Report TR311)).

As part of the 2015 geotechnical survey, vibrocores were taken across the Sizewell site corresponding to areas where proposed infrastructure installations would occur (Figure 1). Samples were analysed for chemical and heavy metal contaminants (see section 3.1 for details). Radionuclide sampling show that concentrations in marine sediments at Sizewell are low (with many values below the limit of detection) and consistent with routine local radionuclide monitoring by the Environment Agency.

In addition to Cefas Action Levels (described in section 3.1), evidence can be drawn from the Interim Canadian Sediment Quality Guidelines (ISQGs). Although not specific to the UK the guidelines are commonly used to assess sediment quality. The guidelines provide threshold effect levels (TELs) and probable effect levels (PELs). The guidance for ISQGs is as follows:

- Below TEL - Minimal effect range within which adverse effects rarely occur.
- Between TEL and PEL - Possible effect range within which adverse effects occasionally occur.

- Above PEL - Probable effect range within which adverse effects frequently occur.

Particle size analysis (PSA) indicated that the majority of the samples consisted of sandy material with low organic carbon content (0.08 – 0.1 OC % inshore and 0.58 – 0.82 % further offshore).

The sediment samples collected at Sizewell indicate that organotin and some heavy metals were below Cefas Action Level 1 and pose no environmental concern. Nickel and Chromium exceeded Cefas Action Level 1 but the highest concentrations reported were less than 25% of Cefas Action Level 2 concentrations and below ISQG PEL concentrations. Arsenic exceeded Cefas Action Level 1 concentrations in six of the samples at different locations and depth profiles. Two samples from the inshore areas (VC18 and VC30) at a sediment depth of 2-2.2m and 5-5.2m showed the highest levels of arsenic, close to, but not exceeding the Cefas Action Level 2 of 100 mg/kg (measurements of 84.7mg/kg and 91.5mg/kg). High levels of arsenic have been reported in the region under similar studies (for example see Galloper Wind Farm Limited 2015). The elevated levels of arsenic at location VC18 and VC30 are not associated with any other elevated contaminants of anthropogenic origin and are found only sub-surface, and as such are considered to be representative of the natural geology and not anthropogenic contamination. It is noteworthy that these locations do not coincide with the dredging sites and therefore these sediments are no expected to be disturbed.

PBCs and organotin were below detection levels in most samples and where detected were considerably below the relative Action Level 1 levels.

Polyaromatic hydrocarbons (PAH) and total hydrocarbon content (THC) exceeded Cefas Action Level 1 for some determinants (no Cefas Action Level 2 exists for hydrocarbons). Elevated levels above the PEL for dimethyl naphthalenes occurred in eleven samples. All other determinants were below PEL limits. A further method to examine PAHs in marine sediments involves assessing levels of grouped PAHs based on their origin and effects characteristics, to published effects ranges. Hydrocarbons can be grouped into low molecular weight (LMW) and high molecular weight (HMW) compounds[3]; LWM are typically from oil (termed 'petrogenic') sources, are highly volatile so evaporate quickly, have high solubility and are easily absorbed across cell membranes and are acutely toxic and carcinogenic. HMW are typically derived from 'pyrolytic' sources (e.g. burning of fossil fuels) they are more pervasive with low volatility, are often bound to particulates in air or sediment and are more persistent in the environment. Effects ranges typically used for assessment include the 'effect range low' (ERL) and the effects range medium (ERM). Effects on biota at concentrations below the ERL are rarely observed however at levels above the ERM effects are generally or always observed. The ERL and ERM values for summer LWM and HMW PAHs are given in (Buchman, 2008) as; 552ng/g (ERL) and 3,160ng/g (ERM) for LWM and 1,700ng/g (ERL) and 9,600 (ERM) for HWM. All values for the sediment samples were below the relative ERM values and all except two samples were below the ERM values. Samples VC10 (surface) and VC24 (surface) marginally exceed the ERL for LWM PAHs (levels of 725ng/g and 793ng/g respectively), however these exceedances are marginal and the ERL should be considered a low point on a continuum of possible effects, furthermore these two locations represent the highest proportions of fines in the surface sediments and therefore can be expected to adsorb relatively higher levels of organic compounds compared to coarser sediments.

The analysis of contaminants from the core samples indicates surface sediments are at, or close to, background levels (i.e. Cefas Action Level 1) or are shown to be considerably below the levels at which biological effects could be anticipated. Elevated arsenic levels, although still below Cefas Action Level 2, are observed in sub-surface samples from >2m below the seabed. The only pathway for disturbance of these sub-surface sediments would be dredging or drilling. The locations of elevated arsenic are >160m from the currently proposed dredging site (FRR2), dredging at this site is expected to cover a footprint of 9m by 23m, and therefore it is currently considered unlikely that these sediments would be disturbed by the proposed works. Furthermore, the acceptability of material for dredging and disposal will require a contemporary

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[3] Low Molecular Weight (LMW: naphthalene, methyl naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene) and High Molecular Weight (HMW: fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[a]pyrene, dibenz[a,h]anthracene)

assessment at the time of dredging which will consider the specific details of the dredging requirement and, if necessary, obtain and interpret new sediment samples.

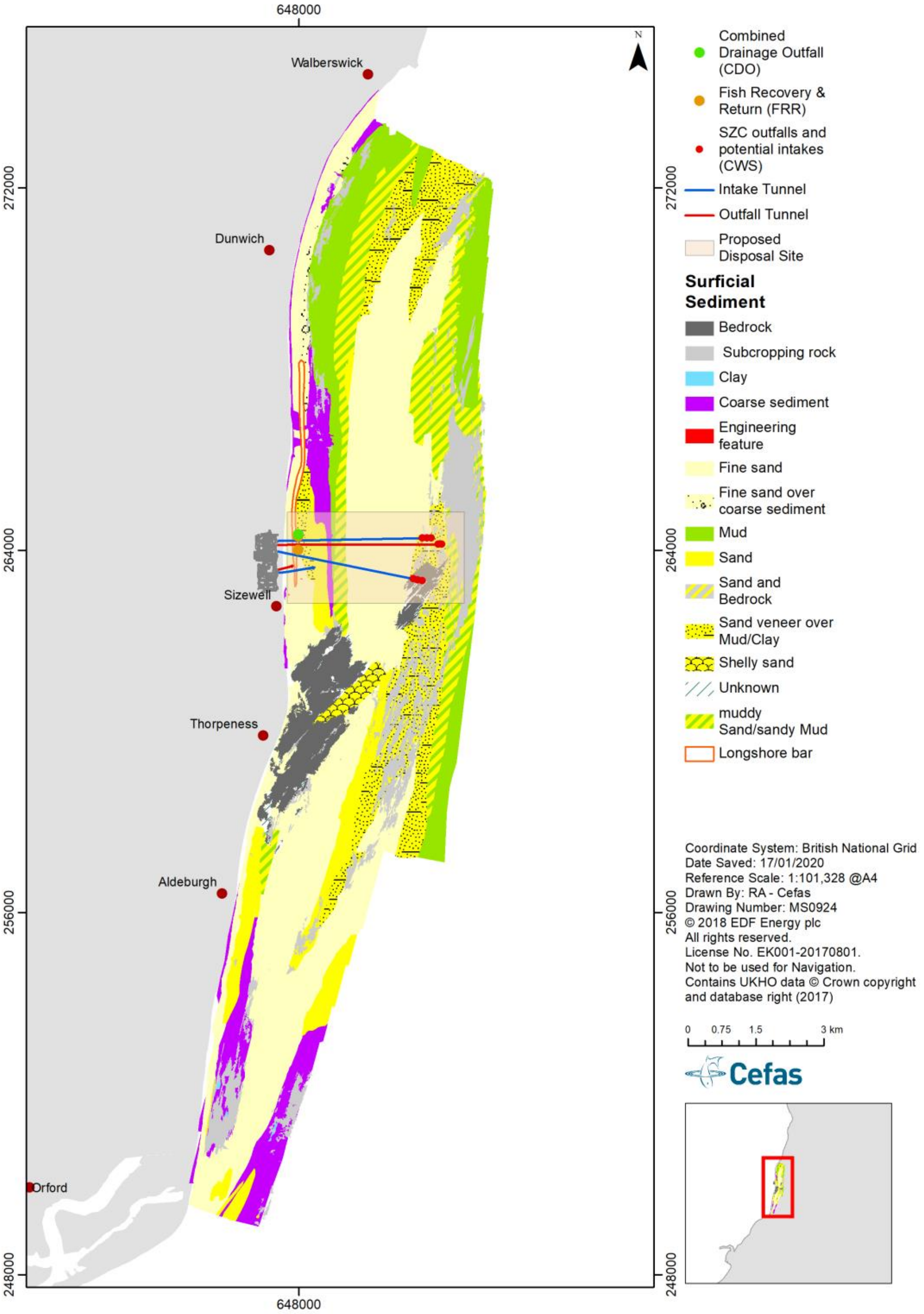

Figure 4: Seabed morphology across the Greater Sizewell Bay survey area derived from backscatter and swath bathymetry observations (BEEMS Technical Report TR087).

4.2 Biological environment

The Marine Ecology and Fisheries Environmental Statement (Chapter 22 of Volume to of the DCO application) provides a detailed account of all the impacts associated with development activities at the site, including all pressures associated with dredging. This section identifies the potentially sensitive receptors groups to dredge disposal activities. Full characterisation reports for each receptor group are provided as appendices to the Environmental Statement DCO submission.

4.2.1 Plankton Ecology

The plankton ecology, as relevant to the disposal site area, is summarised here, detailed characterisations of the phytoplankton and zooplankton of the Greater Sizewell Bay area are reported in BEEMS Technical Report TR346 and BEEMS Technical Report TR315, available as Appendix 22A and 22B of Volume 2 of the Environmental Statement respectively.

- Phytoplankton

In order to determine the temporal and spatial variability in phytoplankton communities within the Greater Sizewell Bay (GSB), a baseline dataset has been compiled from surveys undertaken as part of the BEEMS monitoring programme in 2012 and 2014, the Environment Agency WFD data from the Sizewell area, from the Cefas West Gabbard site and information from remote sensing of the wider region (BEEMS Technical Report TR346). Additional monthly surveys were completed as part of the BEEMS monitoring programme between March 2014 and January 2017 (BEEMS Technical Report TR454). These surveys included sampling sites at the location of the current Sizewell B intakes, the Sizewell B outfalls and the proposed location of the Sizewell C cooling water infrastructure, approximately 3km offshore. A reference site 5.8km to the north of Sizewell was also sampled.

Phytoplankton cell numbers and biomass (chlorophyll *a*) is highest during the “spring bloom” in May. A seasonal succession occurs in community composition; however, the system is heavily dominated by diatoms (2-500µm) year-round. Other groups such as microflagellates (2-20µm) become relatively more abundant in mid-Summer to Autumn, and dinoflagellates, accounting for a smaller proportion of the community composition, peak in abundance in August and September. A large degree of interannual variation in chlorophyll *a* biomass and abundance has been observed for all sites sampled therefore the predicted effects from the proposed development will be given in context with the high natural variation. The phytoplankton communities observed at Sizewell are broadly consistent with the wider geographic area.

Phytoplankton have ecological value due to their role as primary producers and support coastal food webs. Phytoplankton do not have direct conservation designation but the food webs they support contain designated species. Characteristic taxa (at least 10% of the total abundance) include: Chain forming diatoms, *Paralia sulcata*; *Chaetoceros sp.*, *Skeletonema sp.*, Raphiated pennate diatoms; *Thalassiosira sp.*, and *Asterionellopsis glacialis. Other taxa such* as the microflagellate *Phaeocystis sp.* (may cause foam blooms), and some species of Pseudo-nitzschia diatoms (toxic species) have also been considered in the assessment for potential socio-economic effects on fisheries, recreational beach users and the power station.

- Zooplankton

Zooplankton include the early life stages of fish (ichthyoplankton), benthic organisms and invertebrates that are planktonic throughout their life cycle (holoplankton). This section considers the holoplankton component of the zooplankton community as the ichthyoplankton are considered as a life-history stage in the fish ecology section.

The community has been characterised based on data acquired during zooplankton monitoring surveys in the GSB between 2009 and 2017 (BEEMS Technical Report TR315 and BEEMS Technical Report TR454). Entrainment monitoring from 2011 is also applied to inform the zooplankton baseline (BEEMS Technical Report TR318). Sampling primarily took place from February to July, during the period of highest zooplankton biomass in order to describe spatial and temporal variability in zooplankton abundance and community composition. Over time, the spatial extent of the survey changed from a wide geographic area within the GSB tidal excursion (2009 to 2012) to a focus on the Sizewell B intake/outfall and the proposed location for Sizewell C intake/outfall (2014 to 2017).

Over 120 zooplankton taxonomic groups have been identified in the characterisation reports including; mysids, ctenophores, gammarid amphipods, polychaete larvae, hooded shrimps (cumacea), jellyfish, *Crangon* spp, decapods, nematodes, isopods and krill. The characteristic taxa observed at Sizewell are typical of the species found in the wider southern North Sea. None of the holoplankton have direct conservation value. Key zooplankton taxa selected are based on ecological importance and potential socio-economic importance. None of the invertebrate zooplankton taxa have direct commercial value.

These key taxa are: Mysids (ecological value), gelatinous zooplankton (socio-economic and ecological value), Amphipods (ecological value) and Copepods (ecological value). Bentho-pelagic mysids peak in abundance off Sizewell in May-June and show a high degree of interannual and spatial variability. Higher abundances were recorded in the waters within the Sizewell-Dunwich Bank as well as potential aggregations of mysids near the Sizewell B cooling water outfalls. ctenophores peak in abundance in July. Amphipods, primarily of the family Gammaridae, were present throughout much of the year in the Sizewell surveys. Amphipods are typically benthic or epibenthic making periodic excursions into the water column. Finally, copepods are a highly diverse group of holoplankton including adult and juvenile stages of harpacticoids, cyclopoids and the numerically dominant calanoid orders and are present in the water all-year round.

4.2.2 Benthic ecology and habitats

The benthic ecology, as relevant to the disposal site area, is summarised here, a detailed benthic characterisation of the Greater Sizewell Bay area is reported in BEEMS Technical Report TR348, available as Appendix 22C of Volume 2 of the Environmental Statement.

Benthic biota has been characterised to support the Sizewell C environmental assessment in surveys from 2008 to 2017. Pertinent surveys include 11 subtidal grab surveys (with a total of 890 grab samples) and quarterly beam trawl (2m) surveys from 2008 to 2014 collecting 295 trawls from 84 stations. Note that the high degree of sampling effort was dictated by the extent of operational discharges from the Sizewell C development and not the disposal site or dredging assessment.

In the shallow subtidal and subtidal zones, the same broad infaunal and epifaunal benthic community spans most of the Greater Sizewell Bay. Both the infauna and epifauna communities are common in a regional context and are part of a larger community distributed across the south of the North Sea ‘infralittoral region’, corresponding to subtidal areas less than 50m deep. The infauna community is naturally slightly to moderately disturbed[4] showing a shift between April and August when erratic pulses of abundance (settlement events) are recorded, corresponding to the recruitment period. The abundant taxa found in the Greater Sizewell Bay have a high reproduction rate suggesting that infaunal populations are resilient to the dynamic environment of the Great Sizewell Bay.

The characterisation process identified “key” benthic taxa (defined as those of ecological, socio-economic or conservation importance) (Table 4). While two species were identified due to their conservation importance, this importance should be contextualised. The lagoon sand shrimp *Gammarus insensibilis*, protected under Schedule 5 of the Wildlife and Countryside Act 1981, is typically associated with saline lagoons but was observed outside of this habitat in the GSB, occurring at low abundance in the subtidal zone in June 2010. The Ross worm *Sabellaria spinulosa* is listed under Section 41 of the NERC Act (2006) when it forms biogenic reefs. It is also of international conservation importance under the EU Habitats Directive of 1992 when it forms reefs in Special Areas of Conservation (SACs) that are designated for habitat protection, though this does not apply to the GSB and surrounding Southern North Sea SAC. It is therefore not considered a key taxon *per se*, but in that it is foundational to a habitat of conservation importance.

Hard substrate, Coralline Crag, is present in the area which is locally unusual among the soft sediments typically found within the Greater Sizewell Bay – identified as bedrock on Figure 4. Surveys of the Coralline

[4] According to the measure of sensitivity of infaunal benthic communities to disturbance calculated with the AZTI Marine Biotic Index (AMBI) (BEEMS Technical Report TR3).

Crag formation indicate the presence of *S. spinulosa* reefs on the Coralline Crag outcrops that are directly off Thorpeness (inshore Coralline Crag) (BEEMS Technical Report TR473) and on the outcrops seaward of the Sizewell-Dunwich Bank (offshore Coralline Crag) (BEEMS Technical Report TR512) in the location of the proposed southern cooling water infrastructure. *Sabellaria spinulosa* reefs habitat is listed under Section 41 of the NERC Act (2006) as a habitat of conservation importance. *Sabellaria spinulosa* reef is also protected as an Annex I habitat under the EU Habitats Directive (1992), but this only applies within Special Areas of Conservation (SACs). *Sabellaria spinulosa* reefs within the Sizewell area are not located inside a SAC. The potential impacts and resultant effects of the proposed development on *S. spinulosa* reefs are considered in detail within the Environmental Statement (Chapter 22; Marine Ecology and Fisheries in Volume 2). This report considers the direct effects of dredge disposal on *S. spinulosa* pertaining to smothering and changes in suspended sediment loads.

Table 4: Overview of the Key benthic taxa of the Greater Sizewell Bay.

Faunal Group	Taxon	Ecological	Socio-economic	Conservation
Molluscs	*Abra alba*			
	Buccinum undatum			
	Ensis spp.			
	Limecola balthica			
	Mytilus edulis			
	Nucula nitidosa			
	Nucula nucleus			
Crabs and lobsters	*Cancer pagurus*			
	Homarus gammarus			
Shrimps and prawns	*Bathyporeia elegans*			
	Gammarus insensibilis			
	Corophium volutator			
	Crangon crangon			
	Pandalus montagui			
Polychaetes	*Nephtys hombergii*			
	Notomastus spp.			
	Scalibregma inflatum			
	Spiophanes bombyx			
	Sabellaria spinulosa			
Echinoderms	*Ophiura ophiura*			

4.2.3 Fish ecology

The fish ecology, as relevant to the disposal site area, is summarised here, a detailed fish characterisation of the Greater Sizewell Bay area is reported in BEEMS Technical Report TR345, available as Appendix 22D of Volume 2 of the Environmental Statement.

Fish have been characterised from surveys and impingement sampling from Sizewell B (fish caught on the intake screens for the cooling water system). Impingement sampling was carried out between 2009 and 2013. Dedicated fish surveys included ten demersal fishing surveys carried out over a 4-year period; quarterly in 2008, once each in June 2009 and June 2010, and quarterly between June 2011 and March 2012, sampling was conducted using two different fishing gears – a 2m beam trawl and a commercial otter trawl. Plus, a coastal pelagic fish survey carried out in March and June 2015. Additional information was also taken from other nearby developments and inshore fishing surveys off the Suffolk coast and international stock assessments.

A total of 88 fish taxa were identified in the Greater Sizewell Bay area. Forty species were identified in the 2 m beam trawl catches, 25 in the commercial otter trawl catches and 71 species were identified during impingement sampling. This is a likely reflection of the differences in sampling effort, with more sampling during the impingement programme increasing the likelihood of encountering less abundant taxa.

The characterisation process identified “key” fishes (defined as those of ecological, socio-economic or conservation importance) (Table 5). Of the taxa recorded, six are designated as key on the grounds of socio-economic importance, 16 on the grounds of conservation importance and 13 on the grounds of ecological importance. Several taxa fall under more than one of the three criteria and four under all three (Atlantic herring, cod, European plaice and Dover sole). Sixteen taxa of conservation importance are known to be present in the winder area. Two of these (Atlantic salmon and sea lamprey), were not recorded in any of the characterisation surveys, while 3 others (sea trout, European eel and smelt) were only recorded from the onshore impingement monitoring.

Fish spawning and nursery grounds intersect with the disposal site, but the GSB represents only a small proportion of the total spawning/nursery areas. Indeed, high intensity spawning grounds of Dover sole, and low intensity nursery grounds of Dover sole and plaice, intersect the GSB. But these ecologically important grounds are also present in the region surrounding the GSB. Low intensity spawning grounds for herring are present in the area and generally, higher herring spawning intensities are evident beyond the GSB. Sprat nursery grounds are considered to coincide with the GSB, and high intensity nursery grounds of herring intersect the GSB. Low intensity nursery grounds of, whiting, cod, thornback ray, and mackerel also occur within the GSB, yet these are also evident in the region surrounding the GSB (Coull et al., 1998; Ellis et al., 2012).

- Marine fish

Marine fish are considered in the assessment as four subgroups: demersal fish and elasmobranchs, pelagic fish, ichthyoplankton, and spawning and nursery grounds. Taxa of these subgroups that are abundant, commercially important or of conservation importance have been included as key taxa (Table 5).

- Migratory fish

Within the GSB, seven migratory fish species were recorded during the impingement programme as well as the juvenile European eel survey and smelt survey. These included: smelt, European eel, Allis shad, Twaite shad, river lamprey, sea lamprey, and sea trout. Atlantic salmon are also considered for assessment purposed despite not being identified in any surveys within the GSB. Those species are included in list of key taxa for the purpose of the assessment (Table 5).

- Fish as prey of designated species

Effects on the abundance and distribution of fish as a marine prey species from impacts arising from the proposed development are considered in relation to designated seabirds and marine mammals (harbour porpoise and seals). The predominant prey species for designated marine mammals and seabirds at Sizewell include: sprat, herring, anchovy, whiting, seabass, Dover sole, gobies, and dab (Table 5).

Table 5 Overview of the Key fishes of the Greater Sizewell Bay (those in grey were not found in surveys).

Taxon		**Socio-economic**	**Ecological**	**Conservation**
European sprat	*Sprattus sprattus*			
Atlantic herring	*Clupea harengus*			
Whiting	*Merlangius merlangus*			
European sea bass	*Dicentrarchus labrax*			
Sand gobies	*Pomatoschistus* spp.			
Dover sole	*Solea solea*			
Dab	*Limanda limanda*			
Anchovy	Engraulis encrasicolus			
Thin-lipped grey mullet	*Liza ramada*			
European flounder	*Platichthys flesus*			
Atlantic cod	*Gadus morhua*			
European plaice	*Pleuronectes platessa*			
Smelt	*Osmerus eperlanus*			
Thornback ray	*Raja clavata*			
European eel	*Anguilla anguilla*			
Horse mackerel	*Trachurus trachurus*			
Twaite shad	*Alosa fallax*			
River lamprey	*Lampetra fluviatilis*			
Mackerel	*Scomber scombrus*			
Sea trout	*Salmo trutta*			
Allis shad	*Alosa alosa*			
Tope	*Galeorhinus galeus*			
Atlantic salmon	*Salmo salar*			
Sea lamprey	*Petromyzon marinus*			

4.2.4 Marine Mammals

Marine mammals that may be found in the Sizewell area are described in BEEMS Technical Report TR324, available as Appendix 22E of Volume 2 of the Environmental Statement.. Seven species of marine mammal have been recorded in the southern North Sea and a further two in the central and northern North Sea. Of these nine species, three can be considered 'commonly encountered' in the southern North Sea – the harbour porpoise *Phocoena phocoena*, the common/harbour seal *Phoca vitulia* and the grey seal *Halichoerus grypus* – while the others are considered unlikely to occur in the proposed development area and can be classed as 'irregular visitors' or 'passing migrants' (the white beaked, bottlenose and short beaked common dolphins *Lagenorhynchus albirostris*, *Tursiops truncatus* and *Delphinus delphis*) or 'rarely encountered' (minke whale *Balaenoptera acutorostrata*, Atlantic white sided and Risso's dolphins *Lagenorhynchus acutus* and *Grampus griseus*). The three common species are key marine mammal species in the assessment of effects of the proposed development.

4.3 Designated sites of nature conservation importance

The Shadow Habitats Regulations Assessment (HRA) submitted as part of the DCO application (EDF Energy, 2020b) deals specifically with likely significant effects (LSE) of the proposed development on European Sites. Fifty statutory European Sites located within the area of the Sizewell C NNB proposed development sites were assessed under the HRA Regulations and ES.

Dredge and drill disposal have the potential to either directly, or indirectly affect qualifying features of designated sites. The likely implications of these works has been assessed on relevant European Site with marine components (Table 6). Potential impacts from disposal of dredge or drill arisings effecting the ability for designated species to forage or effects on prey resources is also considered. Sites where no impact pathway from dredge and drill disposal activities could be identified were screened out of this report such as sites with terrestrial component only (Dew's Ponds SAC and Sandlings SPA), as well as distant breeding seabird SPAs/Ramsar sites (Stour and Orwell Estuaries). All details can be found in the shadow HRA (EDF Energy, 2020b).

Table 6: Relevant statutory designated sites for birds and marine mammals and associated marine prey species (From BEEMS Technical Report TR341).

Statutory designated site	Description of site features relevant to dredging impacts.
Minsmere to Walberswick Ramsar site (located adjacent to the north-east boundary of the Main Development Site)	Identified as a Ramsar site as it supports a diverse range of wetland bird species in nationally important numbers.
Minsmere to Walberswick SPA (located adjacent to the north-east boundary of the Main Development Site)	The SPA supports breeding, wintering and passage bird populations of European importance, including breeding populations of marsh harrier (*Circus aeruginosus*), bittern (*Botaurus stellaris*), avocet (*Recurvirostra avosetta*) and little tern (*Sterna albifrons)*.
Alde-Ore Estuary Ramsar site (located approximately 5.5km south of the Main Development Site)	Identified as a Ramsar site for its diverse and nationally important wetland bird species
Alde-Ore Estuary SPA (located approximately 5.5km south of the Main Development Site)	The SPA supports bird populations of European importance, including breeding populations of avocet, little tern and sandwich tern (*Sterna sandvicensis)*, and over-wintering ruff (*Philomachus pugnax*). The site also supports important migratory populations of lesser black-backed gull (*Larus fuscus*) during the breeding season and redshank (*Tringa tetanus*) during the winter. The site also supports a seabird assemblage of international importance (including little tern, sandwich tern, lesser black-backed gull, black headed gull *Larus ridibundus* & herring gull *Larus argentatus).*
Benacre to Easton Bavents SPA (located approximately 15km north of the Main Development Site)	The site qualifies by supporting the following species: Breeding and over wintering bittern *Botaurus stellaris*, breeding little tern *Sterna albifrons* and breeding marsh harrier *Circus aeruginosus*.
Outer Thames Estuary SPA (includes the area of open sea adjacent to the eastern boundary of the Main Development Site)	The Outer Thames Estuary SPA qualifies by supporting populations of European importance of wintering Red-throated diver *Gavia stellata*, breeding little tern *Sterna albifrons* and Breeding Common Tern *Sterna hirundo.*
Deben Estuary SPA	The site qualifies by supporting overwintering populations of avocet (*Recurvirostra avosetta*)
Deben Estuary Ramsar site	The Deben Estuary supports: a population of the mollusc *Vertigo angustior*; and an over-winter population of dark-bellied Brent goose, *Branta bernicla bernicla*
Southern North Sea SAC (includes the area of open sea adjacent to the eastern boundary of the Main Development Site)	The Southern North Sea site is designated for the Annex II species harbour porpoise (*Phocoena phocoena*) for both winter and summer seasons.

Statutory designated site	Description of site features relevant to dredging impacts.
Humber Estuary SAC	The site is site is designated for the Annex II species Grey Seal
The Wash and North Norfolk Coast SAC	The site is site is designated for the Annex II species harbour Seal

4.4 Human environment

Following the OSPAR 2014 guidelines, evaluation of other users and socio-economic factors should be considered, as appropriate, when designating a new disposal site.

4.4.1 Commercial and recreational fisheries

Commercial and recreational fishing activity in the Sizewell area is described in BEEMS Technical Report TR123, available as Appendix 22F of Volume 2 of the Environmental Statement..

An assessment of the level and nature of fishing activity in the Sizewell study area revealed that commercial fishing boats from Lowestoft, Southwold, Dunwich, Aldeburgh, Orford and Felixstowe may fish in the area at various times of the year, although only <10 m boats are operated from the beaches at Dunwich and Sizewell throughout the year. In January and February, fishers target cod with nets and longlines within two miles of the coast, continuing into March and April when rays start appearing on longlines. Fixed and drift nets are fished close inshore to take bass, sole and mackerel through the Summer. The boats also set pots for brown crabs and lobsters in Spring and Summer and may use driftnets during Autumn and Winter to catch herring and sprat. A hobby fisherman at Sizewell also uses pots for crab and lobster for personal consumption. In all, 19 angling charter boats were operating in the area in 2014, though none would be considered full-time (fishing for 4 or more days per week).

4.4.2 Shipping and navigation

The marine navigation is described in the marine traffic survey report (Anatec Limited, 2014; Anatec Limited, 2015).

A total of 28 days of Automatic Identification System (AIS) data was used to inform the baseline shipping analysis. These were taken from shore-based surveys undertaken in August 2016 (14 days Summer) and between November/December 2015 (14 days Winter). A study area was defined as a 12nm buffer around the proposed development.

In Summer an average of 72 vessels were observed per day, 15% were commercial fishing vessels with recreational vessels accounting for 22% and cargo vessels representing 24% of the total. In Winter, cargo vessels accounted for nearly 50% of vessel activity with fishing contributing a further 10%. Other frequently recorded types include wind farm support vessels, dredger/subsea vessels, passenger vessels and tankers.

During the summer months, the cooling water outfall/intake positions are located within an area of higher vessel density due to the abundance of small craft activity. Other high-density areas can be attributed to the north/south route, approximately 6nm east of the proposed development, for transient traffic identified in the study area. This main route is utilised by commercial vessels transiting to various ports within the Humber Estuary and Thames Estuary for example. High traffic levels (commercial ferries and cargo in particular) are also associated with the Sunk traffic separation scheme, located approximately 20nm south of the Sizewell C development.

4.4.3 Marine Archaeology

The marine historic environment is described in the PEIR (EDF Energy, 2019a) and it considers all known heritage assets within the main development site offshore zone (below the mean high-water mark (MHWM)).

The PEIR includes a review of existing records of archaeological features and investigations as well as environmental assessments commissioned by EDF Energy, regional syntheses, published and unpublished academic material. These secondary sources were supplemented by archaeological assessment of available, and recently acquired, geophysical (swath bathymetry, sub-bottom, side-scan sonar, magnetometer and backscatter data) and geomorphological (LiDAR, geo-rectified historic maps) data of the offshore region.

Results identified no designated sites below the MHWM within 5km of the main development site therefore the potential effects of dredging and dredge disposal in not assessed further in this report.

4.4.4 Beaches and recreational use

Amenity and recreation resources within the 1km study area around Sizewell C development site are described in the PEIR (EDF Energy, 2019a). These resources comprise public footpath (Public Right of Ways) and cycle routes. There are no designated bathing waters on the Sizewell beach.

There is therefore no pressure pathway for the dredging and dredge disposal to affect these receptors, so no further assessment is proposed.

4.4.5 Other users

Few other potential marine users have been recorded as part of the marine navigation section of the PEIR (EDF Energy, 2019a).

- There are no marine aggregate dredging areas within proximity of the proposed development. The closest aggregate dredging areas are production areas located approximately 12-13nm south and 14nm east of the proposed development.
- Export cables associated with Galloper and Greater Gabbard Offshore Wind Farms (OWF), in addition to the Concerto 1 North telecommunication cable, all lie within 1nm south of the proposed outfall/intake positions.
- There are no Ministry of Defence practice or exercise areas within proximity of the proposed development. The closest area lies 18nm south-east of Sizewell C.
- The closest operational wind farm relative to the proposed development is the Greater Gabbard OWF, located approximately 18.5nm to the south-east.
- Southwold anchorage is the closest anchorage area to the proposed development (6nm north). Hallesley Bay (12nm from proposed development) and Sledway (14nm from proposed development) also offer anchorage to vessels further south.
- The operational power station Sizewell B and the decommissioned Sizewell A power station are located immediately south of the proposed development.

These users will not be affected by the dredging and dredge disposal in the GSB so no further assessment is proposed in this report.

5 Assessment of potential effects

The assessment of potential impacts of dredging material disposal and drill arisings follows the impact assessment methodology rational described in the EDF Energy EIA Scoping Report (EDF Energy, 2019c). The impact matrix used is provided in Table 7 below. Significance has been assigned for the relevant receptors in the physical and biological environment below.

Table 7: Impact assessment matrix used to assess the significance of potential impact of the Sizewell C new nuclear build.

Magnitude of Impact	Sensitivity of Receptor			
	High	**Medium**	**Low**	**Not Sensitive**
High	Major	Major	Moderate	Minor
Medium	Major	Moderate	Minor	Minor
Low	Moderate	Minor	Minor	Negligible
Very Low	Minor	Minor	Negligible	Negligible

The pressures associated with dredging and dredge material disposal that have a potential to impact the physical and biological environment are:

- Change in suspended sediments
- Sedimentation rate change

Some pressures were scoped out of further assessment as they have been deemed to have negligible effects on physical and biological receptors. These include:

- Contaminant resuspension – sediment samples from across the Sizewell site were analysed for chemical and heavy metal contaminants including heavy metals, insecticides, organotin, particle size, organic and chlorinated compounds as well as radionuclides. Following these analyses, the sediments within the GSB are considered to be uncontaminated (Section 22.1b) and the effects of resuspension of contaminants on benthic receptors is not considered further.
- The potential for in-combination effects arising from dredging and disposal activities occurring coincidentally has been assessed. Based on the expected construction sequence, identified activities which could occur in-combination would be the dredging for the Beach Landing Facility (BLF) approach channel[5] which could occur coincident with dredging of either the CWS structures or the additional outfall structures (CDO or FRR). The potential effects of in-combination pressure have been assessed in the ES and showed that assessment significance remain unchanged for all receptors.

5.1 Physical environment

5.1.1 Coastal processes

The spoil from dredging would be disposed of within 500m of each extraction site and detailed 3D modelling provides a description of the sediment dispersion in the GSB (see section 2.1.2). At the nearshore sites (CDO, FRR) this will allow the sediment to be retained within the longshore transport system. Considering the dredge spoil from each infrastructure location is disposed at one location and forms a mound of the seabed, this initially creates a deposit 20mm thick close to the disposal point with patches 5mm thick

[5] To accommodate the safe passage of barges and accompanying tugs to the BLF, a navigational channel and grounding area would be required in the nearshore zone occupied by the two longshore bars. Plough dredging is the preferred option to create a planar surface for the barges to come aground. Plough dredging agitates the sediment, which is then transported away by the tide (EDF Energy, 2020a).

possibly forming within 7-8km. As sediment presence has a low instantaneous extent and duration, the impact on substrate change and local hydrodynamics is very low. The suspended concentration change would be undetectable within two days of release.

In the worst-case scenario of the offshore CWS intakes and outfalls being dredged sequentially, deposition up to 1m thick would occur at the disposal site, reducing to 10mm within 1km. The disposal mound would be re-mobilised and deposited over several tidal cycles, shrinking in size with the passage of each tide, such that only 5% remains within the Sizewell C development area after a full spring-neap cycle. The remaining undispersed sediment would finally settle 23km to the south, and its thickness would be less than 10mm. These bed level changes would have an undetectable effect on hydrodynamics or geomorphic features. The assessment assumes that the spoil is not directly disposed of onto the Sizewell-Dunwich Bank.

Disposal of dredge spoil from a single head would lead to a peak SSC at the disposal site itself but it will be falling to less than 50mg/L above background everywhere within 6 hours.

Following the full assessment in the ES (EDF Energy, 2020a) the effect of dredge spoil disposal on costal processes is assessed as ***negligible*** and not significant.

5.1.2 Sediment and water quality

Dredging and local dredge disposal for the installation of each headworks (CDO, FRR or CWS) would lead to elevated suspended sediment concentrations (SSC). Dredging at each site headwork have been considered as temporarily distinct events as it is likely that each infrastructure would be installed separately. The plumes with instantaneous SSC of 100mg/L above background levels[6] are expected to form at the surface over areas of up to 391ha (see Table 8 for details). Instantaneous SSC of >1,000mg/l above background levels are predicted to affect smaller area of up to 34ha at the surface. The elevated concentrations are shown to decay to background levels within circa two days on both spring and neap tides after the completion of the disposal operations (BEEMS Technical Report TR480). Ambient conditions at the site are highly variable and surface waters are considered as '*intermediate turbidity'* according to WFD criteria (WFD, 2015). Dredging and disposal at either of the three infrastructures sites would temporarily increase the classification to '*turbid'*.

Marine waters at Sizewell are well mixed (see section 4.1) such that localised elevations of SSC quickly redistribute and return to background levels therefore the impact of increased SSC resulting from dredging/disposal activities for the installation of the headwork is predicted to have a ***minor adverse effect*** for each component (CDO, CWS, FRR) on water quality and sediment, as assessed in the ES (EDF Energy, 2020a). Effects are predicted to be short-lived and not significant relative to natural variation.

Table 8: Predicted areas (ha) of maximum Suspended Sediment Concentration (SSC) in the surface layer of the model resulting from the dredging of surficial sediment for the installation at each of the marine infrastructure components (CDO, CWS and FRR).

Components	Instantaneous SSC of >100mg/l above background levels	instantaneous SSC of >1,000mg/l above background levels
Combined Drainage Outfall	89	1
Cooling Water System	391	34
Fish Recovery and Return	89	1

[6] Survey work at Sizewell carried out as part of the BEEMS project in 2009 and 2010 show that the inshore daily maximum background SSC is in the range 357 to 609mg/l at 0.3 m above the seabed and 266 to 459 mg/l at 1m above the seabed. The background SSC at the surface ranges between 9 to 436mg/l inshore and between 28 and 246mg/l offshore (close to the planned intake and outfall structures, BEEMS Report TR480).

5.2 Biological environment

5.2.1 Plankton

Phytoplankton exposed to increases in SSC may be susceptible to reductions in productivity. The short duration and transitory nature of the plume suggests that a small decline in primary productivity may occur, but recovery would be rapid following cessation of the dredging and disposal activity. The impact of increased SSC resulting from dredging activities for the installation of each structure (CDO, FRR and CWS) is predicted to have a ***minor adverse effect*** on phytoplankton as per the ES (EDF Energy, 2020a). Effects are predicted to be short-lived and not significant relative to natural variation.

Increases in SSC may have adverse effects on fitness of some zooplankton taxa by decreasing ingestion rates and/or egg production rates. Effects are likely to be species specific and dependent on natural food availability however high natural fecundity and exchange with the wider southern North Sea afford a high degree of resilience.

Sedimentation may be sufficient to cause localised mortality of zooplankton with a benthic association in close proximity to the dredge activity where sediment thicknesses exceed 50mm. However, zooplankton are predicted to be resistant to sedimentation levels expected throughout much of the impacted area and any losses would be expected to recover quickly due to the temporary nature of the dredge activities.

The impact of increased SSC and increased sedimentation rates resulting from dredging and dredge disposal activities for the installation of each structure (CDO, FRR and CWS) is predicted to have a ***minor adverse effect*** on zooplankton as per the ES (EDF Energy, 2020a). Effects are predicted to be short-lived and not significant.

5.2.2 Benthic ecology

- Benthic invertebrate

As described in section 4.2.2, the same broad infaunal and epifaunal benthic community spans most of the Greater Sizewell Bay so the benthic invertebrate taxa potentially affected by changes in SSC and sedimentation rate changes associated with dredging and dredge disposal are similar for each marine infrastructure installation site (CDO, FRR and CWS).

The focus of the assessment of an increase SSC is placed on invertebrate suspension-feeders as adults (as they filter their food from the water column) and those that have planktonic larvae that feed in the water column (‘planktotrophic’ larvae). Most benthic invertebrate taxa in the GSB (including *G. insensibilis*) in the area predicted to be affected by changes in SSC are not suspension-feeders as adults and are therefore unlikely to be affected by increases in SSC during the adult life-stage. Three key taxa (the razor clam *Ensis* spp., blue mussel *Mytilus edulis*, and Ross worm *S. spinulosa*) are obligate suspension feeders and could therefore be vulnerable to elevated SSC. However, this does not appear to be the case as these taxa are often found in areas of high turbidity. Indeed, some suspension-feeders with high particle selection efficiency and pseudofaeces production can be tolerant of, or even respond positively to, increased concentrations of suspended fine sediments (Hawkins et al., 1996). It is therefore unlikely that populations of suspension-feeders would be adversely affected by elevated SSC associated with dredging and disposal activities. Moreover, if benthic invertebrates were to be adversely affected by elevated SSC, most species within the affected area (including the suspension-feeding key taxa) have traits that allow rapid recolonization.

Only a small area of seabed at the CWS location is expected to be exposed to greater than a ‘light’ deposition with just 7ha expected to experience sediment deposition in exceedance of 50mm per headwork dredge event. Within this area, it is assumed that only the low mobility (sessile) organisms will be affected by smothering due to sediment deposition. Indeed, high mobility organisms are expected to be able to resurface rapidly or migrate away from the affected area. At the community level, sediment deposition resulting from dredging and dredge disposal can reduce the number of benthic invertebrate species and individuals within the affected area, however, the effect of dredge disposal on such community metrics may be insignificant when occurring amid a background of natural ecological variability. Moreover, the key taxa and broader benthic invertebrate community that would be exposed to changes in sedimentation rates are widely distributed within the GSB and the wider region. Therefore, only a small proportion of any benthic invertebrate population would be exposed to this pressure and, as such, its capacity to reduce population densities is limited.

Most benthic invertebrates in the GSB have pelagic eggs and planktotrophic larvae and would therefore be vulnerable to any effects of elevated SSC in the water column. The potential effect of increased SSC on larval stages includes reduced food availability for planktotrophic larvae (extending larval development period during which time organisms are particularly vulnerable to predation) or, on the other hand, increased turbidity could make planktonic eggs and larvae less conspicuous to predators. There is therefore no clear evidence that planktotrophic larvae would be adversely affected by elevated SSC and moreover, if planktotrophic larvae were adversely influenced by elevated SSC, their high natural mortality means that effects would likely be indiscernible from background levels.

The changes in SSC and sedimentation rate change associated with dredging/disposal activities for marine infrastructure installation is predicted to have a ***minor adverse*** to ***minor beneficial effect*** on this receptor, as per the ES (EDF Energy, 2020a). The effect is not significant relative to natural variation.

- *Sabellaria spinulosa* reefs

The area of increase in SSC and sedimentation intersect with inshore *Sabellaria spinulosa* reefs due to dredging and dredge disposal for the FRR and CDO and with the offshore reefs due to dredging and dredge disposal for the CWS. This report considers the direct effects of dredge disposal on *S. spinulosa* pertaining to smothering and changes in suspended sediment loads. The full suite of potential impacts and resultant effects of the proposed development on *S. spinulosa* reefs are considered in detail within the Environmental Statement (Chapter 22; Marine Ecology and Fisheries in Volume 2).

The proximity of the offshore *S. spinulosa* reefs to the proposed location of the southern (Unit 1) cooling water intakes (Figure 1) means they are potentially the most sensitive. However, the background SSC at the offshore *Sabellaria spinulosa* reefs is characterised by very high SSC loads with winter averages of approximately 500mg/l and maximum values of over 2,000mg/l 1.4m above the seabed (BEEMS Technical Report TR311). As such, dredge plumes are comparatively small relative to natural background conditions.

Sabellaria spinulosa reefs are often found in areas of high turbidity, including the immediate vicinity of aggregate dredging sites where sediment plumes are common (Gibb et al., 2014). Therefore, any effects of elevated SSC on suspension-feeding by *S. spinulosa* do not appear to be a major factor limiting reef distribution. On the contrary, *S. spinulosa* relies on a supply of suspended solids to build tubes that form the reef structure, and tube erosion occurs when the supply is insufficient (Davies et al., 2009). Therefore, reef building by *S. spinulosa* is unlikely to be impeded, and short-term increases in tube growth may occur due to changes in SSC associated with dredging and dredge disposal. However, given the natural variability and high maximum concentrations experience at the site it is likely that any beneficial effects of dredge plumes would be minor. Sediment suspended by dredging for the installation of CWS infrastructure could be deposited on *S. spinulosa* reef. However, this is anticipated to be light <10mm and subject to tidal erosion. *Sabellaria spinulosa* reefs are not anticipated to be sensitive to sedimentation rate changes associated with dredging activities.

In addition to dredging, *S. spinulosa* at the offshore reef would be exposed to drill arisings following drilling for the vertical connection shafts. The shafts would be drilled through the centre of the cooling water intakes *in-situ* to connect the headworks to the subterranean cooling water tunnels. Spoil piles, consisting of relatively coarse particles (>1mm), would form in the vicinity of the drill sites. The extent of the footprint would be dependent on the release depth and tidal conditions. The spoil pile would form a conical shape with deepest deposits of coarse material closest to the drill site and shallower smaller sized deposits at greater distances. Assuming release at the surface, and given the local flow conditions and water depths, the coarsest fractions of sediment (>10mm) are expected to settle within 60m of the drill site. Particles sizes of 1mm would be deposited within 200m of the drill site. A gradient in sediments depths would occur with deepest deposits (up to meters) at the drill site with mean deposit depths of 0.5m to 50mm radiating from the source. Spoil deposits would be eroded during periods of strong tidal flow, associated with spring tides and during storms. As such the impact would be short-term.

A precautionary approach assumes drill arisings are sufficient to cause smothering and mortality of *S. spinulosa* reef where the thickest deposition of coarse material is anticipated. To encompass the full range of pressures associated with the installation of the intakes (beyond the scope of this report) the Environmental Statement considered a 50m buffer zone surrounding the intakes as the potential area where construction impacts (including drill spoil arisings) may occur. A worst-case scenario assumption for the inter-relationship effect with other construction activities assumes loss of reef within the 50m buffer zone. The worst-case scenario would result in between 4 to 6% (depending on the location of the headworks) of the existing reef area at the offshore Coralline Crag would be lost. Beyond the area where deep burial may lead to smothering and mortality of *S. spinulosa* reefs, shallower deposition of smaller particles sizes (1mm) would occur but would also be dispersed rapidly during spring flows. *Sabellaria spinulosa* can survive deep burial for periods of days up to several weeks during which time tubes can continue to be built and may extend to the sediment surface when deposition is light or occurs gradually (Earl and Erwin, 1983, Last et al., 2011). It is therefore unlikely that reef habitat would be adversely affected outside the immediate area of deepest deposition close to the drill site.

Pressures associated to dredging and dredge disposal from the marine infrastructure installation is predicted to have a ***minor adverse*** to ***minor beneficial effect*** on this receptor as per the ES (EDF Energy, 2020a). The effect is not significant relative to natural variation.

5.2.3 Fish ecology

Marine and migratory fish may be affected by increases in suspended sediment concentration from construction dredging and dredge disposal. Sensitivity has been assessed in the ES (EDF Energy, 2020a) for different subgroups, at the sea-area or regional stock/population level, and for each infrastructure component (FRR, CDO, CWS).

- Marine Fish

The potential for direct mortality and sub-lethal effects for demersal fish larvae, pelagic eggs and larvae and elasmobranch cases exists including to gill trauma and a reduction in reproductive success. However, losses are generally considered minimal compared to natural mortality and the presence of the taxa could be maintained through natural influxes of eggs and larvae. The adults of these subgroups exhibit the ability to compensate for increases in SSC or may be able to avoid areas with elevated SSC and return once SSC returns to ambient levels. The plume is also unlikely to inhibit foraging ability. The limited magnitude persistence and transitory nature of the plume means the likelihood for fish to be displaced entirely from the plume area and not return is very limited.

Adults and juveniles of demersal and pelagic fish as well as elasmobranch have the capacity to compensate and to temporary sediment deposition or move away from the area. Eggs, egg cases and larvae can be affected by smothering associated by a local increase in sedimentation, however, no declines in abundance and distribution of the respective stocks/populations are expected because the losses are considered minimal compared to the loss of eggs/larvae due to natural mortality occurring within the extensive spawning and nursery grounds of the GSB.

Overall dredging and dredge disposal pressures are predicted to have a ***minor adverse effect*** on marine fish as per the ES (EDF Energy, 2020a). The effect is not significant relative to natural variation.

- Migratory fish

SSC plumes have the potential to influence migratory behaviour due to plume avoidance. However, the transient nature of dredge plumes is unlikely to restrict the route of migratory species as they may choose to move freely around the plume. No barrier to the migratory movement is predicted.

Migratory glass eels may be susceptible to changes in sediment deposition rates when they burry into the seabed, however deposition rates are typically light and eels would be able to emerge from all but the highly localised areas of heavy deposition. No declines in stock/population for any migratory species are predicted.

Overall dredging and dredge disposal pressures are predicted to have a ***minor adverse effect*** on migratory fish as per the ES (EDF Energy, 2020a). The effect is not significant at the sea area and regional stock/population levels.

- Fish as prey species

The avoidance of fish to SSC plumes, notably pelagic fish, would be influenced by factors such as motivation, mobility and condition. Fish may exhibit limited movements away from the areas of SSC, remaining in proximity to the plume and utilising the area once the plume dissipates. Should the passage of the plume influence fish behaviour, particularly those of ecological value as prey species of designated sea birds the potential exists for temporary reductions is foraging success of designated species. Given that the limited persistence and transitory nature of the plume, the scope for fish to be displaced entirely from the plume area and not return is very limited.

Localised displacement of fish receptors near the disposal site may occur in the areas of maximum sedimentation. However, displacement would be temporary and would not significantly changes in the availability as prey items for designated features and as fisheries resources.

Overall dredging and dredge disposal pressures are predicted to have a ***minor adverse effect*** on fish as prey species as per the ES (EDF Energy, 2020a). The effect is not significant at the sea area and regional stock/population levels.

5.2.4 Marine mammals

Harbour porpoise and seals are well adapted to existence in turbid coastal waters and reduced visibility does not affect foraging as they are using echolocation to navigate. As the increase in SSC and sedimentation rate is unlikely to affect significantly the prey population of fish, there would not be a significant effect of this pressure on marine mammals foraging in the area.

The impact of dredging and dredge disposal associated to installation of marine structure (CDO, FRR and CWS) is ***negligible*** as per the ES (EDF Energy, 2020a). Effects are predicted to be short-lived and not significant compare to conditions already found in the area.

5.3 Designated conservation sites

The potential impact of offshore works associated with Sizewell C development on the designated marine features of European Sites (including SPAs, SACs and Ramsar sites) is considered the in Habitats Regulations Assessment (HRA) process (EDF Energy, 2020b). Potential impacts from dredging and disposal works have been assessed for Likely Significant Effects alone (LSE) and in combination with other plans and projects (LSIE) to determine whether the proposed development would have an adverse effect on the integrity of these European sites. The outcome of the assessment for coastal habitats, birds, marine mammals and migratory fish are detailed in Table 9.
No ***adverse effects*** are expected on these designated features of European Sites.

Table 9: Summary of the outcome of the screening exercise for Likely Significant Effects (LSE) and Likely Significant In-combination Effects (LSIE) in the Shadow HRA (EDF Energy, 2020b), as well as significance of the assessment for the potential impact of dredging and disposal works on designated Marine European sites.

Statutory designated site	Screening results	Significance
COASTAL HABITATS		
Minsmere to Walberswick Ramsar site	No LSE / no LSIE	No adverse effects
Alde-Ore Estuary Ramsar site	No LSE / no LSIE	No adverse effects
BIRDS		
Minsmere to Walberswick Ramsar site	No LSE / no LSIE	No adverse effect

Statutory designated site	Screening results	Significance
Minsmere to Walberswick SPA	LSE* / LSIE**	No adverse effect
Alde-Ore Estuary Ramsar site	No LSE / no LSIE	No adverse effect
Alde-Ore Estuary SPA	No LSE / no LSIE	No adverse effect
Benacre to Easton Bavents SPA	No LSE / no LSIE	No adverse effect
Outer Thames Estuary SPA	LSE* / LSIE**	No adverse effect
Deben Estuary SPA	No LSE / no LSIE	No adverse effect
Deben Estuary Ramsar site	No LSE / no LSIE	No adverse effect
MARINE MAMMALS		
Southern North Sea SAC	LSE***/no LSIE	No adverse effect
Humber Estuary SAC	LSE ****/ no LSIE	No adverse effect
The Wash and North Norfolk Coast SAC	LSE ****/no LSIE	No adverse effect
MIGRATORY FISH		
Humber Estuary SAC	No LSE / no LSIE	No adverse effect

*Increases in SSC associated with dredging and dredge disposal of the marine infrastructures has the potential to have effects on the prey availability of SPA qualifying features (breeding little tern and common tern) however based on the relatively small extent of overlap of the SPA foraging ranges with the different predicted SSC plumes, combined with the temporary and short-term duration of the activity, no adverse effects on the SPA populations are predicted.

**The screening exercise for plans or projects that could potentially cause a LSIE with the construction and operation of the Sizewell C Project identified possible LSIE on the Minsmere-Walberswick SPA. The changes to coastal processes / sediment transport due to the Sizewell C Project would be very small, local to the Project, and too far away to interact with the other project in the area. It is concluded that the Sizewell C Project would not result in adverse in-combination effects on the integrity of the Minsmere-Walberswick SPA.

***In the context of the Southern North Sea SAC, the maximum area of change in water quality (approximately 0.06% of the SAC), any potential effect would not exceed either the 20% threshold of effect at any one time or exceed the 10% seasonal component of the SAC on average over the season. Consequently, no direct adverse effect on the integrity of SAC is predicted due to Sizewell C main development site construction phase in relation to the conservation objectives for harbour porpoise.

**** The limited information available indicates that increased turbidity, as a result of dredging, is unlikely to have a substantial direct impact on marine mammals. However indirect effects can be expected on their fish prey, sensitive to excessive suspended sediment, with a potential range of effects, from mortality to gill trauma and a reduction in reproductive success. The assessment however shows that as the maximum predicted impact area for any increased suspended sediments is the same for grey seals as it is for their prey, there would be no additional impacts on individuals as a result of the effects of any changes to water quality on prey species.

5.4 Impacts on other receptors

Potential effects pathways on ‘commercial and recreational fisheries’ as well as on ‘shipping and navigation’ have been identified in section 4.4. The potential impact of dredging and dredge disposal activities on these receptors have been assessed in the ES (EDF Energy, 2020a) and are summarised below.

- Commercial and recreational fisheries

During the installation of offshore infrastructure hierarchical safety buffer zones of 250m to 500m depending on the activity and stage of construction would likely be applied surrounding dredging vessels. These safety buffer zones would be implemented through Notice to Mariners (NtM). EDF Energy has a history of offshore operations within the area and has developed and maintained communications with fishers prior to offshore surveys. Where survey requirements and fishing activity coincide, necessary arrangements have been agreed to mitigate against any conflict. Such communications would be expected to continue throughout the construction phase.

Various fishing vessels commercially use the area and the assessment presented in the ES (EDF Energy, 2020a) concluded that netters, potters long-liners, otter trawlers would not be significantly affected by the pressure as the area of the safety buffer are temporary and would only represent a minor proportion of the fishing area. As the area represents a minor proportion of the area for boat anglers they would not be affected, no significant changes are expected for the recreational fisheries.

The increase in SSC and sedimentation rate has been considered in the ES (EDF Energy, 2020a) to assess potential change in availability of target species of finfish, but also benthic invertebrates. Indeed, commercially valuable species such as crab and lobster are targeted at the area of the Coralline Crag. Dredge activities are short-term and suspended sediment plumes are predicted to be transient, returning to baseline levels within days of dredging being completed. Sedimentation as a result of dredging and dredge disposal activities is anticipated to be light and naturally high resuspension rates mean sediment deposits would not persist. Effects on commercial species are predicted to be minimal with no subsequent implications for the fishery.

The loss of access on commercial and recreational fisheries and effects on shipping and navigation in the dredging and disposal area is therefore predicted to have a ***minor adverse effect*** as per the ES (EDF Energy, 2020a).

- Shipping and navigation

Safety buffer zones surrounding installation vessels are spatially and temporally restricted and are predicted to have minimal impact on the passage of vessels to fishing grounds (i.e. the increases in steaming times and fuel costs associated with avoiding safety buffer zones). Due to the limited proposed disposal volume, water depth in the area and general dispersive nature of the environment, no risk to navigation is anticipated (i.e. reduction in water depth to a point of creating a hazard for vessels).

The loss of access on shipping and navigation in the dredging and disposal area is therefore predicted to have a ***negligible*** as per the ES (EDF Energy, 2020a).

5.5 Summary of impacts

As summary of the potential impacts on the physical and biological environment is provided in Table 10 below. Dredging and drilling activities are not considered to represent significant effects.

Table 10: Summary of assessed impacts of significance for the dredge and dredge disposal activities.

Receptors		Significance
	Coastal processes	**Negligible**
	Sediment and Water quality	**Minor adverse effect**
Plankton	Phytoplankton Zooplankton	**Minor adverse effect** **Minor adverse effect**
Benthic Ecology	Benthic invertebrates: *Sabellaria spinulosa* reefs:	**Minor adverse** to **minor beneficial effect** **Minor adverse** to **minor beneficial effect**
Fish Ecology	Marine fish Migratory Fish Fish as prey species	**Minor adverse effect** **Minor adverse effect** **Minor adverse effect**
	Marine Mammals	**Negligible**
	Designated conservation sites	**No adverse effect**
Other receptors	Commercial and recreational fisheries: Shipping and navigation:	**Minor adverse effects** **Negligible**

6 Monitoring

It is likely that each infrastructure (CDO, FRR and CWS) would be installed separately and over a short period of time. Therefore, due to the temporary nature of the disposal of dredge and drilling material activities and as the impacts have been predicted to be negligible to minor adverse and not significant, no monitoring is proposed (beyond ensuring sediment quality is suitable for disposal as sea, as described in Section 3.2.

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