CHAPTER 11: BENTHIC ECOLOGY AND INTERTIDAL ECOLOGY

Technical Summary

Surveys were undertaken to characterise the marine plants and animals on the seabed within the Seagreen Project areas. The Project Alpha and Project Bravo sites were found to be typical of the region and contained large areas of featureless, sediment dominated seabed with patchy communities of worms and shellfish. The only species of conservation importance found to be living within Project Alpha and Project Bravo sites was the long lived ocean quahog, however only small numbers of young specimens were identified. The Ross worm was present across the site which is a common and widely distributed species of high conservation value when found growing in reef structures. However, there was no evidence that these worms were forming reef structures within the surveyed areas. A slightly more diverse range of species and habitats were found along the export cable route corridor but no further species of conservation importance were identified. A survey of the landfall location at Carnoustie indicated it to be typical of a sand beach with few species present. Of those identified the majority were worms or marine snails.

The direct impact on habitats and species through the installation of substructures/ foundations, subsea cables and associated infrastructure is considered to be of short term duration and not significant. Indirect impacts from sediment disturbance and deposition resulting from construction activities is also considered to be not significant due to the natural levels of suspended sediment movement and the tolerance of the bottom living community to such disturbances and impacts. Following construction there is the potential for scour to occur around substructures/ foundations. The scoured areas, the structures and any scour protection are expected to be readily colonised by species from adjacent areas and may cause a localised increase in biodiversity providing feeding opportunities and refuge habitats for a range of species. Overall, no impacts are assessed to be significant in EIA terms and no cumulative impacts are anticipated with other projects.

INTRODUCTION

11.1. This Chapter of the Environmental Statement (ES) describes ecology of the seabed (benthic ecology) and the foreshore below the mean high water mark (intertidal), both within the Seagreen Project and the wider Northern North Sea. Other aspects of marine ecology are covered elsewhere in this ES, for example, Chapter 12: Natural Fish and Shellfish Resource and Chapter 13: Marine Mammals.

11.2. Chapter 9: Nature Conservation Designations, Chapter 10: Ornithology and Chapter 8: Water and Sediment Quality have inter-relationships with this Chapter and are cross referenced as appropriate.

11.3. This Chapter characterises the distribution and abundance of benthic species and habitats known to occur within the Seagreen Project and the wider northern North Sea region, as established through site specific or regional surveys. The Chapter then presents the assessment made of potential impacts of the construction, operation and decommissioning phases of the Seagreen Project. Proposed approaches to mitigation of these impacts are also discussed.

11.4. This section of the ES was written by Royal Haskoning, and incorporates results and advice from other contributors including Envision Mapping Ltd (Envision) and The Institute of Estuarine and Coastal Studies (IECS). Technical reports from IECS and Envision are included as Appendices G1 and G2, which can be found along with all other appendices in ES Volume III: Appendices. All figures referred to in this Chapter can be found in ES Volume II: Figures.

CONSULTATION

11.5. Table 11.1 summarises issues highlighted by the consultees in the Scoping Opinion (Marine Scotland, January 2011) and during further subsequent consultation. The table also indicates which section(s) of this or other chapters address the issues raised.

Table 11.1 Summary of consultation and issues

Date	Consultee	Issue	Response or relevant chapter/section
June 2010	Marine Scotland	Agreement of the Benthic sampling plan	Appendix G1 which can be found in *ES Volume III* outlines the survey plan
September 2010	Marine Scotland Licensing Operations Team (MS LOT)	Presentation of sampling plan and method statement.	Appendix G1 which can be found in *ES Volume III* outlines the survey plan that was presented to Marine Scotland on the 23 September 2010
September 2010	MS LOT	Preliminary discussion of approach to benthic sampling strategy and methods	Appendix G1 and G2 which can be found in *ES Volume III*.
January 2011	Scottish Natural Heritage (SNH) and Joint Nature Conservation Committee (JNCC)	Sandy substrates are potentially important. The Environmental Impact Assessment (EIA) should fully assess the potential impacts on this habitat type.	Impact Assessment of this Chapter
January 2011	SNH and JNCC	Value of extent lost or disturbed should be considered relevant to the particular habitat distribution within the development area (which will vary in vulnerability), and the effects on the processes which serve to maintain the habitat features and its associated communities.	Impact Assessment of this Chapter
January 2011	SNH and JNCC	Scottish Government published a draft list of Priority Marine Features for which Marine Protected Areas (MPAs) may be an appropriate mechanism. SNH (for Scottish Territorial Waters (STW)) and the JNCC (for offshore waters) have since published complete lists.	Impact Assessment- Worst Case Scenario of this Chapter.
January 2011	Scottish Environment Protection Agency (SEPA)	All submissions should include information on likely timing and duration of the project, possible long-term locational and/ or operational impacts and short-term construction impacts.	Presented in Chapter 5: Project Description
January 2011	SEPA	A baseline assessment of existing intertidal and subtidal habitats and species should be submitted as part of the ES.	Existing Environment of this chapter.

Date	Consultee	Issue	Response or relevant chapter/section
January 2011	SEPA	Please note that populations of *Ostrea edulis* have been found recently in the Firth of Forth. There is a need to ensure that this United Kingdom Biodiversity Action Plan (UKBAP) species are not present where works are proposed	No *Ostrea edulis* were identified during either the benthic survey campaign or in the intertidal surveys. Data available through the National Biodiversity Network (NBN) gateway indicates that this species has been identified in the southern Firth of Forth on the coast to the west of North Berwick, but not in the vicinity of the Seagreen Project.
January 2011	SEPA	During the construction phase, it is important that good working practice is adopted and that habitat damage is kept to a minimum and within defined acceptable parameters. These should be controlled through an environmental management plan	An environmental management plan will be completed prior to the commencement of any construction works.
January 2011	SEPA	The sub-tidal survey should also include a visual element as specified above, to identify possible habitats or species of conservation importance.	As part of the benthic survey campaign a drop down video sampling survey was completed, details can be found in Section 11.3 and Appendix G2 which can be found in *ES Volume III*
March 2011	MS LOT	Agreement of sampling strategy in terms of method, effort and distribution.	Appendix G1 which can be found in *ES Volume III*
August 2011	MS LOT	Agreement of approach to sample analysis.	Appendix G1 which can be found in *ES Volume III*

ASSESSMENT METHODOLOGY

Study Area

11.6. This Chapter focuses on two different scales of study area:

- the Wider Study Area (WSA); and
- the Immediate Study Area (ISA) (both of which are displayed in Figure 11.1).

11.7. The WSA, consideration of which will provide context for data collected from the ISA, is defined as the northern North Sea regional sea[1] (as defined in the Review of Marine Nature Conservation (RMNC), Joint Nature Conservation Committee (JNCC) 2004 and Department of Environment, Food and Rural Affairs (Defra) 2004).

11.8. Benthic surveys were conducted prior to the delineation of the separate offshore wind farms (OWFs), known as Project Alpha and Project Bravo, and were carried out over areas referred to as the Phase 1 area and the export cable route (ECR) corridor, with two potential landfalls (one at Arbroath and one at Carnoustie) included. Therefore data has been collected from outside the current ISA and this data is made use of within the assessment.

1 Regional Seas are biogeographic subdivisions of the wider sea. They provide an appropriate scale at which to assess marine biological resources, and the physical and chemical processes that these depend on (JNCC, 2004).

11.9. It should be noted that the cumulative impact discussion documents developed by The Forth and Tay Offshore Wind Developers Group (FTOWDG) in 2010 / 2011, highlighted that there is limited potential for the proposed Seagreen Project and Scottish Territorial Waters (STW) developments in the Firths of Forth and Tay, to affect benthic ecology outside of their ISAs. Cumulative impacts on benthic ecology are therefore only considered further in the context of the magnitude of impact and sensitivity of receptor habitats and species.

11.10. Cumulative impacts in the benthic environment arise from the additive loss of habitat resulting from a number of developments over time. As the habitats under consideration are extensive and do not contain features of high conservation importance, the potential impact significance arising from the loss of areas of benthic communities due to installation of OWF infrastructure is likely to be minimal.

11.11. The terrestrial boundary for the Seagreen Project is delineated by the Mean High Water Spring (MHWS) tidal limit. All onshore works (being assessed as part of a separate Environmental Impact Assessment (EIA)) terminate at Mean Low Water Spring (MLWS) tidal limit. This results in an overlap of study areas between the offshore and onshore developments. This approach follows that adopted for previous Round 1 and Round 2 OWFs.

Data Collection and Survey

Survey strategy

11.12. The surveys were carried out in accordance with a scope of works agreed in consultation with Marine Scotland on the 23 June 2010. This scope of works was based upon standard methodologies (Saunders *et al.*, 2011, Boyd, 2002; Proudfoot *et al.*, 1997). Marine Scotland in turn consulted on the proposed approach with their statutory nature conservation advisors (JNCC and Scottish Natural Heritage (SNH)).

11.13. The approach to the survey involved the use of benthic grabs, towed video and benthic trawls to collect both physical and biological information across the ISA. The aim of the survey was to collect sufficient data to characterise the ISA in order to allow potential impacts to be assessed. The survey was not designed to form a baseline for future monitoring of potential impacts, as the need for such monitoring had not yet been identified while the design and layout of the Seagreen Project was still being developed. Sample locations for the offshore benthic survey are shown in Figure 11.2 and Figure 11.3. The locations for the intertidal survey are also shown in Figure 11.3.

Offshore Surveys

11.14. Although a number of different surveys conducted as part of the ISA survey program contribute to the overall understanding of the marine ecology, it is primarily those which are described in this Chapter under the title of 'benthic survey', which have been used as the main source of baseline information. The benthic survey incorporated a sampling regime that covered the entirety of the ISA which includes both ECR landfall options originally under consideration. All benthic survey work was completed during February to April 2011 IECS, using the survey vessel MV Clupea. The subsequent sample analysis was completed by September 2011.

11.15. The benthic survey consisted of three elements which were:

i. grab sampling: targeting infaunal species (species within the sediment);

ii. beam trawl sampling: targeting epibenthic species (species living upon the seabed); and,

iii. drop down video sampling: targeting species which may be mobile enough to escape the beam trawling or species which may be damaged should the beam trawl be deployed.

Infaunal grab sampling

11.16. A total of 169 grab sampling stations were identified within the ISA (150 within the original Phase 1 area, and further 19 were identified later within the ECR corridor). Station locations were identified using two criterion: Firstly both the geophysical data (See Chapter 7: Physical Environment of this ES for details of this data) and a nautical chart were used to select locations where features on the seabed may lead to the presence of rare or protected habitats and/ or species; secondly stations were positioned in order to ensure that reasonable coverage across the entire ISA occurred.

11.17. Due to the rocky nature of the seabed, no infaunal samples could be retrieved from five of the 169 grab stations, despite several (five) attempts being made to collect a sample at each of these locations. However, an approximate assessment of the sediment type was recorded and a VideoRay drop down video system was deployed at each grab station to collect supporting video footage.

11.18. A mini Hamon grab (0.1 square metres (m^2)) was deployed to collect a single replicate sample for infaunal analysis, from which a Particle Size Analysis (PSA) sample was also taken. At 50 grab stations a second grab was collected for sediment contaminant analysis the results of which are presented in Chapter 8: Water and Sediment Quality (further detail on methodology and results are displayed in Appendix G1 in ES Volume III).

11.19. A full survey log was maintained throughout the survey detailing station number, time of sampling, position (Differential Global Positioning System (DGPS) derived), water depth, volume of sample, physical characteristics of the sample, a digital image of each sample and any other relevant features were noted, such as the presence of Ross worm Sabellaria spinulosa individuals.

11.20. After collection, the infaunal samples were processed on a sequential basis utilising a nested sieving technique and the contents preserved and stored appropriately on board and transported back to the laboratory for taxonomic identification. Full details of the survey methodology can be found in Appendix G1 in ES Volume III. It was agreed with Marine Scotland that 100 of the 145 infaunal samples collected[2] across the ISA should be analysed fully and that the remaining 45 should remain preserved. The additional 45 samples were to be analysed if significant features of interest such as Sabellaria aggregations or mature ocean quahog Arctica islandica were identified by other aspects of the benthic survey.

Epibenthic trawl sampling

11.21. A total of 53 epibenthic trawl sample stations were identified within the ISA (50 within the original Phase 1 area and a further three in the ECR corridor) (see Figures 11.2 and 11.3 in ES Volume II: Figures). Station locations were identified using two criterion: Firstly both

2 Note that five grab samples failed. Five attempts were made to get a sample for each grab station

the geophysical data (See Chapter 7: Physical Environment for details of this data) and a nautical chart were used to select locations where features on the seabed may lead to the presence of rare or protected habitats and/ or species; secondly stations were positioned in order to ensure that reasonable coverage across the entire ISA occurred.

11.22. A VideoRay underwater camera system was deployed at each of the epifaunal trawl stations before sampling took place to verify the absence (in significant amounts) of habitats of potential conservation interest (i.e. Sabellaria reef or *Modiolus* reef) and to provide additional information on the nature of the seabed. Further details on VideoRay are given in the following sub-section.

11.23. Following the deployment of the VideoRay system, a 2 metre (m) beam trawl with a 5m long net, 40 millimetre (mm) mesh liner inside, and a 5mm (knot to knot) square mesh cod end liner was deployed in close proximity to the video line. The trawl was lowered from the survey vessel to the seabed at the predetermined start point and towed for approximately 10 - 20 minutes over a path of approximately 500m while maintaining a speed of between 1 - 1.5 knots.

11.24. The trawl line was logged using DGPS at the start (lock of the winch) and end of the trawl (engagement of the winch). The 1m cod end with 5mm mesh was hauled aboard with the aid of a lifting rope to ensure the cod end was lifted independently of the beam. A single tow was carried out at each identified trawl line.

11.25. Any large specimens were identified on board the vessel, recorded, photographed and then returned to the water. The remaining catch was transferred to a clean labelled bucket and fixed using 4% formo-saline solution and transported to the laboratory for taxonomic identification. All fish were measured to the millimetre below (total length or an appropriate measure in case of species with extreme body shape; i.e. skates and rays) and these measurements form a separate data source that is used in Chapter 12: Natural Fish and Shellfish Resource in this ES.

11.26. Further details of the equipment used and the methodology can be found in Appendix G1 in ES Volume III which was approved by Marine Scotland (Table 11.1)

Video sampling

11.27. A drop down video camera was deployed prior to each beam trawl. The system was a VideoRay Pro 3 XE Professional Remotely Operated Vehicle (ROV), connected to a control panel with a 15 inch colour display via an umbilical cable, allowing real time analysis of video footage. Footage was also captured on mini digital video cassette and external hard drive.

11.28. Field notes were taken recording sediment type, epifauna (including potential biogenic reefs) and any observed obstructions at each deployment.

11.29. The video footage was then analysed and the species present, sediment type and any other points of interest were recorded. Each sample station was assigned biotope codes using The Marine Habitat Classification for Britain and Ireland v04.05 (Connor *et al.*, 2004). A preliminary classification of habitats was made by IECS; this was then used to inform the habitat mapping work of Envision described in the following sub-section.

11.30. Further detail of the equipment and methodology used during video sampling are presented in Appendix G1 found in ES Volume III.

Post survey analysis

11.31. The data collected during the benthic survey was combined with geophysical data collected during an earlier geophysical campaign (As presented in Chapter 7: Physical Environment) and used by Envision to create a habitat map for the ISA. The method used by Envision which is detailed in Appendix G2 which can be found in ES Volume III involved a number of different techniques summarised as follows.

11.32. Infaunal data from across the ISA were combined with PSA data and analysed using the multivariate analysis including CLUSTER and SIMPROF routines in PRIMER[3] V6 to produce habitat classes. One habitat class (*faunal turf*) was defined using the video data only as it was not possible to collect grab samples where hard substrata are present.

11.33. Geophysical data which could be associated with the biological habitat classes (or Folks classes) were used to create a statistical 'signature' for each class. These signatures were then applied to the whole geophysical data set. This worked well for the ECR corridor area; however, the results for the remainder of the ISA indicated a lack of discriminatory power that resulted in a high level of confusion between classes.

11.34. A second approach was used to map the habitat across the remainder of the ISA. This involved the point sample data from video and grabs being used to derive probability images of occurrence for each habitat classification that reflect spatial trends.

11.35. The resultant sediment maps are shown in Figures 11.4 and Figure 11.7 (Project Alpha and Project Bravo sites and ECR corridor respectively), with habitat models shown in Figure 11.5 and Figure 11.9 (Project Alpha and Project Bravo area and ECR corridor respectively). Envision also produced a map (Figures 12 and 13 available in Appendix G2 which can be found in ES Volume III.) which shows the certainty of their allocation of habitat types across the ISA. This shows that Envision have generally a high certainty that the habitat classes produced by the modelling are correct.

Intertidal Survey

11.36. Two cable landfall options were considered. These are south Arbroath beach and Carnoustie. Surveys of these sites were conducted on the 29 and 30 September 2011 and the resultant report (including methodology) is presented in Appendix G3 which can be found in ES Volume III. The survey covered all areas of the intertidal foreshore from MHWS to MLWS that may be directly affected by the cable installation works.

11.37. The survey was conducted according to standard Phase 1 intertidal methodology (Davies *et al.*, 2001). Each landfall location was surveyed along a transect following the centre line of the proposed ECR corridor, with two further transects surveyed 250m north and 250m south of the centre line of the ECR corridor.

11.38. During the walkover survey a qualitative assessment of the abundance of dominant benthic species was performed. Where areas of high species abundance were encountered the assessment was carried out by counting visible indicators such as siphon holes, burrows or casts. Target notes were also made detailing the presence of vegetation, benthic green algae, as well as sediment characteristics. Locations of any notable features were recorded using a handheld GPS.

3 Plymouth Routines In Multivariate Ecological Research version six (PRIMER 6). PRIMER 6 is a collection of specialist routines for analysing, for example, species or sample abundance (biomass).

11.39. As part of the walkover survey, the intertidal biotopes on any bedrock or artificial hard substrata were identified and photographed. An estimate of the abundance and species richness within each of the identified biotopes was made by surveying a $1m^2$ area and noting conspicuous species and their abundance (in terms of percentage cover within the $1m^2$ area). Target notes were made for any notable features, a photograph was taken and the extent of each biotope identified was recorded. Dig-overs were also performed to ascertain the presence of large infauna.

Summary of Key Data and Survey Information Used

11.40. Table 11.2 summarises the key data and surveys used within this Chapter.

Table 11.2 Summary of key data and surveys

Title	Source	Year	Area covered by data	Reference
Offshore Survey	IECS	2011	ISA	Appendix G1 which can be found in *ES Volume III*
Habitat Mapping	Envision	2011	ISA	Appendix G2 which can be found in *ES Volume III*.
Intertidal Survey	Royal Haskoning	2011	Landfall of the ECR corridor (intertidal)	Appendix G3 which can be found in *ES Volume III*.
St. Abbs / Bell Rock sludge-dumping site surveys	Marine Scotland	1998	Sampling approx. 16 kilometres (km) from ISA	Scottish Office Agriculture and Fisheries Department (SOAFD) (undated)
North Sea benthic trawl survey	Marine Scotland	2001 - 2003	Nearest station 14km from ISA	Fisheries Research Services (FRS) (undated)
UK National Marine Monitoring Programme	Marine Scotland	1990 - 1996	Nearest station 8km form ISA	FRS (undated)
Synthesis of Information on the Benthos of Area Strategic Environmental Assessment (SEA) 5	Department of Energy and Climate Change (DECC)	2004	SEA Area 5	Eleftheriou *et al.*, 2004

Approach to Assessment

11.41. The impact assessment follows the standard methodology as presented in Chapter 6 EIA Process in this ES and the description of the Seagreen Project as presented in Chapter 5 Project Description in this ES.

11.42. Each impact included in the assessment was identified through the consultation process (Table 11.1) and previous experience in offshore wind impact assessment. The impacts have been assessed in terms of their significance (Table 11.5).

11.43. Impacts for Project Alpha, Project Bravo and the Transmission Asset have been assessed during Construction (Section 11.6), Operation (Section 11.7) and Decommissioning (Section 11.8). Cumulative and in-combination impacts are assessed in Section 11.9.

11.44. The data sources summarised above in Table 11.2 are used to describe the baseline of the existing environment (Section 11.4). Each impact, which has been identified through the consultation process and previous experience, is then assessed in terms of its significance using the following methods.

11.45. The significance of an impact imposed by the Seagreen Project is based on the intensity or degree of disturbance to baseline conditions and is categorised into four levels of magnitude, high, medium, low or negligible. The descriptions of each of these are given in Table 11.3.

Table 11.3 Criteria for assessing the magnitude of potential impacts on intertidal and benthic ecology

Magnitude of impact	Description
High	Fundamental change to the baseline condition of benthic ecology, resulting in major alteration of the size and or quality of habitats, species or biodiversity.
Medium	Detectable but non-fundamental temporary or permanent consequential changes to the baseline condition resulting in noticeable alteration of the size and/ or quality of habitats, species or biodiversity.
Low	Minor change with only slight detectable changes, which do not (or only temporarily) alter the baseline condition of the receptor.
Negligible	Imperceptible or no change to the baseline condition of the benthic community

11.46. The sensitivity/ value of the receptor for each impact is characterised as one of four levels, high, medium, low or negligible. The description of each level is given below in Table 11.4.

Table 11.4 Criteria for assessing the sensitivity of benthic and intertidal ecology

Receptor sensitivity/ value	Marine fauna and flora importance	Site designations
High	International/ National	Habitats or species that have been identified as highly sensitive and/ or have been designated for their international or national importance (Special Areas of Conservation (SACs), Sites of Special Scientific Interest (SSSIs), National Nature Reserves (NNRs), UK BAP species or habitats).
Medium	Regional	Habitats or species that have been identified as having a medium sensitivity and/ or have been designated for their regional importance (Local BAP species).
Low	Local	Habitats or species that have been identified as having low sensitivity and/ or have been designated locally for their flora or fauna (Local Nature Reserves (LNRs)) or undesignated sites of some locally important biodiversity or habitat.
Negligible		Other habitats or species with little or no locally important biodiversity.

11.47. Table 11.5 combines the descriptions of magnitude with the level of sensitivity/ value of the receptor to provide a prediction of overall significance of the impact. The boxes shaded in red represent an impact which is likely to be considered significant within an EIA context.

11.48. As can be seen from Table 11.5 impacts can range from major to negligible. An impact of moderate or major significance would be considered to be significant in relation to the EIA Regulations.

Table 11.5 Significance prediction matrix

Value / Sensitivity	Magnitude			
	High	**Medium**	**Low**	**Negligible**
High	Major	Major	Moderate	Minor
Medium	Major	Moderate	Minor	Negligible
Low	Moderate	Minor	Negligible	Negligible
Negligible	Minor	Negligible	Negligible	Negligible

EXISTING ENVIRONMENT

11.49. This section reports on the existing environment within the Project Alpha Site, the Project Bravo Site and within the Transmission Asset Project Site and establishes a baseline from which the impact assessment can be made. This section also places these within the context of the wider region (See section 11.3 Study Areas). This section is arranged, starting with the largest geographical area (the WSA) and then focusing on the individual projects.

11.50. The data available to support the descriptions is summarised in Table 11.2 above.

11.51. It should be noted that much of the ISA and WSA has been heavily fished and continue to be fished by bottom contacting gears, particularly by scallop dredges (see Chapter 14: Commercial Fisheries within this ES). This is the only major anthropogenic impact observed upon the benthos to date (also see Chapter 20: Other Marine Users and Activities within this ES).

The Wider Study Area (WSA)

11.52. Elefteriou *et al.* (2004) noted that North Sea surveys (which included the WSA) have been mainly concerned with fish populations and that benthic surveys have been less numerous, resulting in a general lack of understanding of the benthos across the area. Dyer *et al.*. (1982) mapped the abundances of the most common or locally abundant species across the North Sea, with species that occurred in the WSA including the echinoderms *Echinus acutus* and *Asterias rubens*, the polychaete *Hyalinoecia tubicola*, the red sea pen *Pennatula phosporea*, the soft coral *Alcyonium digitatum*, the prawn *Nephrops norvegicus* (also known simply as Nephrops) and the bryozoan, *Flustra foliacea.* Jennings *et al.* (1999) derived two groupings of species free-living epibenthos (characterized by *Asterias rubens*, *Crangon allmanni*, *Pagurus bernhardus*, *Hyas coarctatus*, *Astropecten irregularis* and Anapagurus laevis) and attached species (characterised by *Flustra foliacea, Hydrallmania falcate, Lafoea dumosa, Suberites ficus, Ciona intestinalis* and *Alcyonium diaphanum*).

11.53. Although the WSA has not been subject to recent comprehensive survey (Eleftheriou, 2004), key surveys conducted over the 20th century have been summarised by Elefteriou *et al.* (Eleftheriou, 2004). Basford and Eleftheriou (1988) (cited in Eleftheriou, 2004) undertook a survey extending across the North Sea from just north of Shetland to the Firth of Forth from 1980 – 1985. Abundance varied from 500 individuals per m^2 inshore to the east of Shetland, to 9,600 per m^2 towards the more silty deeper offshore areas, with a mean abundance of 3,300 per m^2. Polychaetes predominated throughout, often comprising 50% of the abundance and generally being between 2 to 5 times as numerous as the molluscs or echinoderms. The number of species varied from 26 at the most northerly station off Shetland, to 80 in deeper silty stations north of the Fladen Ground; the mean species richness was 54 species per station. Jennings *et al.*, (1999) reported that the epifauna of the North Sea south of 57°30'N (encompassing the WSA) was characterised by a mixed fauna including starfish, crustaceans, bivalves and polychaete worms.

The Immediate Study Area (ISA)

11.54. As mentioned above in section 11.3 the ISA comprises the Phase 1 area and both the Carnoustie and Arbroath (now excluded) ECR corridors for which survey data were collected (Figure 11.1). The benthic survey and geophysical survey data was used to determine the habitat maps which cover this study area. The Carnoustie ECR corridor has since been chosen as the cable route to take forward but the data collected across the Arbroath ECR corridor provides useful context and is therefore retained in the analysis.

11.55. Subtidal habitats were classified by Envision post survey based upon the infaunal (grab) data with the incorporation of PSA data and epifaunal data from both the trawl and video surveys. A full description of the methodology used can be found in Appendix G2 of ES Volume III. The initial number of distinct groups (24) was too large to provide successful image classification and so the number of groups was reduced by amalgamation based on species composition. As a result of this process 14 groups were identified and these are summarised in Table 11.6 which also references the equivalent JNCC biotope classification codes (Connor *et al.*, 2004).

11.56. It was decided that due to the differing environments present, the ECR corridor data should be kept separate during analysis. Therefore two of the groups only found within the ECR (Thyasira and Fabulina) were removed from the analysis of the remainder of the ISA, as was the Capitella group as there was only 1 occurrence of this group (see Appendix G2, ES Volume III). The two groups (Thyasira and Fabulina) were then reintroduced for the ECR corridor analysis.

Table 11.6 Groups used in habitat classification

Key / characteristic species	Groups from Primer analysis	Number of sites, community and substrate description	Equivalent JNCC Biotope Code
Capitella	b	1 site. Characterised by large numbers of the polychaete *Capitella* and low numbers of a small range of other polychaetes. Slightly gravelly sand.	SS.SMu.ISaMu.Cap
Dense *Amphiura/ Phoronis*	g	6 sites. *Amphiura/Phoronis* dominated, but also with a range of bivalves. Epifauna sparse and characterised by *Echinocyamus pusillus*. Sand or slightly gravelly sand.	SMu.CSaMu.AfilMysAnit
Dense *Chone*	t	6 sites. Characterised by high numbers of *Chone* and moderate numbers of *Sabellaria* together with a large range of other polychaete species. Rich epifauna including bryozoan hydroid turf, tube worms and *Ascidiella*. Gravelly sand.	SS.SMx.OMx.(Chone)
Epifauna on cobble		6 sites. Identified from video: Cobbles with epifauna of bryozoan and hydroid turf.	SS.SMX.CMX*
Epifauna/ polychaete	r u v w	8 sites. Characterised by rich epifauna including *Ascidiella* and tube-building polychaetes. Infaunal polychaetes also rich. Gravelly sand and sand.	SS.SMx.OMx.PoVen
Fabulina	d	3 sites. Characterised by the bivalve *Fabulina* and other bivalves together with the polychaetes *Magelonia* and *Spiophanes*. Epifauna absent. Slightly gravelly sand or sand.	SSa.IMuSa.FfabMag
Faunal Turf	NA	6 sites. Identified from video: Cobbles with epifauna of bryozoan and hydroid turf.	SMX.CMx.FluHyd
Ophiothrix	pa	4 sites. Characterised by rich epifauna of bryozoans and hydroids and *Ophithrix fragilis*. Infauna sparse. Coarse sediment of sandy gravels.	SMx.CMx.OphMx
Polychaete/ bivalve	n o j	14 sites. Characterised by moderately rich polychaetes and sparse bivalves. Moderately rich epifauna. Similar to the 'sparse polychaete' group but with richer polychaete fauna and fewer bivalves. Gravelly sand and slightly gravelly sand.	SS.SMx.OMx.PoVen
Rich polychaetes	l	22 sites. Characterised by rich polychaete infauna, (particularly *Ophelia* and *Spiophanes*) and bivalves. Moderately sparse epifauna. Similar to the 'polychaetes and bivalves' group but with a greater dominance of *Ophelia*. Gravelly sand, slightly gravelly sand and sand.	SS.SMx.OMx.PoVen
Sabellaria	x	12 sites. Characterised by dense *Sabellaria spinulosa* and rich epifauna of bryozoans and hydroids, *Ascidiella* and faunal crusts. Infauna rich. Coarse gravelly sand.	SBR.PoR.SspiMx
Sparse *Amphiura*	f	5 sites. Dominated by bivalves, but characterised by low numbers of *Amphiura*. Epifauna sparse or absent. Slightly gravelly muddy sand.	SMx.CMx.MysThyMx
Sparse *Chone*	s q	7 sites. Characterised by moderate or low numbers of *Chone*. Moderate epifauna including *Echinocyamus pusillus*. Slightly gravelly sand, gravelly sand and sandy gravel.	SS.SMx.OMx.(Chone)
Sparse polychaete/ bivalve	k m I h c	26 sites. *Amphiura/Phoronis* dominated, but also with a range of bivalves. Epifauna sparse and characterised by *Echinocyamus pusillus*. Sand or slightly gravelly sand.	SCS.ICS.MoeVen
Thyasira	e	2 sites. Characterised by the bivalves *Thyasira* and *Abra nitida* together with low numbers of a small range of polychaetes. Epifauna absent. Slightly gravelly muddy sand or muddy sand.	SCS.CMx

SS.SMX.CMX was Identified by Royal Haskoning as the equivalent JNCC biotope post completion of the Envision Mapping Ltd report.
Source: Envision (Appendix G2 can be found in ES Volume III), note that groups relate to the originally defined sub-sets of the habitats which were then combined to give the resultant habitats listed above.

Project Alpha

11.57. The Project Alpha Site is characterised by water depths ranging between 39m and 61m lowest astronomical tide (LAT). The sediments across the site were characterised by Envision see Figure 11.4 and Appendix G2 which can be found in ES Volume III)From west to east across the Project Alpha Site, the sediments range from cobble with sand and gravelly sand to sandy gravel. The majority of the Project Alpha Site is level or undulating with occasional linear sediment waves.

11.58. The habitats across the site were characterised by Envision using the methodology described above and in section 11.3. A map which is a product of this characterisation is displayed in Figure 11.5. Habitats across the Project Alpha Site can be divided into a western area and a central and eastern area (see Figure 11.5). The western area is dominated by three benthic community classes: 'Sabellaria', 'sparse polychaetes and bivalves', and 'faunal turf' while the central and eastern area is dominated by the sabellid polychaete classes 'dense Chone' and 'Sparse Chone'. There appears to be a clear divide between the two areas, however, 'polychaete and bivalve' habitats are also present in the most northern part of the eastern area. There is also a patch of raised sandy gravel characterised by the brittlestar 'Ophiothrix spp' which is located on or near the boundary between the western and central and eastern areas.

11.59. The infauna and epifauna identified and enumerated during the benthic survey are summarised below in Table 11.7.

Table 11.7 Infauna and epifauna identified as present in the Project Alpha Site

Infauna			**Epifauna**		
Taxa	**Individuals (%)**	**Species (%)**	**Taxa**	**Individuals (%)**	**Species (%)**
Polychaeta	59.5	36.3	Crustacea	67.9	43.8
Mollusca	13.8	14.6	Echinodermata	27.9	25.0
Crustacea	5.9	15.6	Mollusca	3.5	21.3
Echinodermata	5.7	19.9	Polychaeta	0.3	3.8
Tunicata	4.3	0.8	Ascidiacea	0.2	1.3
Nematoda	3.0	0.3	Bryozoa	0.2	1.3
Cnidaria	2.4	2.8	Cniaria	0.1	2.5
Nemertea	1.6	0.5	Pycnogonida	<0.01	1.3
Bryozoa	1.4	7.1			
Others	2.3	2.3			
Total number	**5,642**	**397**	**Total**	**8,340**	**80**

Source: IECS, Appendix G1 which can be found in ES Volume III.

11.60. Abundance of individuals in the infauna ranged from 962 (station G77) to 24 (station G60) and numbers of species ranged from 141 (station G77) to 11 (station G60). Two grab samples within the Project Alpha Site had 8,560 and 9,625 individuals, due to very high numbers of fish larvae and eggs, which have not been included in the above summary table (see Appendix G1 for full details of infauna and species lists). Infaunal abundance and species richness for the Project Alpha Site are shown in Figure 11.6.

11.61. Polychaetes were the dominant group in the infauna with approximately 60% of the individuals and 36% of the species. The most abundant species of polychaetes were *Capitella capitata* with a total of 621 individuals, the majority of which (592) recorded in a single sample (station G76) and *Chone spp.* with a total of 573 individuals, the greatest number of which (361) were recorded at station G77. Molluscs were the next most numerous group, accounting for nearly 14% of individuals, with the bivalve *Moerella pygmaea* the most abundant. Crustaceans accounted for 5.9% of individuals and 15.6% of species; the most numerous crustaceans were the amphipod *Atylus vedlomensis*, and the squat lobster *Galathea intermedia.*

11.62. Crustaceans dominated the epifauna accounting for almost 70% of individuals. The most numerous species being the shrimp *Crangon allmani* and the hermit crab *Pagurus bernhardus.*

11.63. Twenty seven species of fish were also caught in the trawls within the Project Alpha Site, the most abundant species being dab *Limanda limanda, pogge Agonus cataphractus* and sandeel *Ammodytes spp* .(528, 510 and 142 individuals respectively).

11.64. The central section of the Project Alpha Site appears to support slightly more infaunal individuals and species[4] than the northern and western sections (Figure 11.6). The highest numbers of individuals were recorded in samples within the 'dense Chone' habitat of the central section, in areas of sandy gravel (see Figure 11.4, Figure 11.5 and Figure 11.6).

11.65. It is noteworthy that Sabellaria habitat areas, which are located mainly in the western part of the Project Alpha Site (Figure 11.5), are generally diverse in both infauna and epifana, an example of which occurs at trawl sample V21, which has the highest number of species recorded in any video sample and the third highest number of species of any benthic trawl within the Project Alpha Site (Appendix G1 which can be found in ES Volume III.). The high species richness in the Sabellaria habitats is in marked contrast with the sparse polychaete communities which have low infaunal species richness, such as that found at G61. It is possible that the colonisation of suitable areas by Sabellaria increases the species richness of habitats; however, there is no evidence from the video sampling that this species forms extensive or well-developed aggregations at this site, which would potentially qualify as 'reefs' under the Habitats Directive or criteria developed by Gubbay (2007).

11.66. In general, mixed sediments, which allow encrusting fauna such as hydroids, bryozoans and ascidians to flourish, also have their own associated fauna. Common species found from this community include the polychaetes *Pholoe spp., Eulalia spp., Eumida sanguinea, Glycera lapidum, Cirratulus cirratus, Pomatoceros triqueter, Hydroides norvegica, Ampharete lindstroemi, Polycirrus spp.; the bivalves Cochlodesma praetenue, Tridonta montagui, Timoclea ovata, Dosinia exoleta, Hiatella arctica;* and the *ascidian Ascidiella scabra.*

11.67. The sandy sediments supported low abundance and species richness. Again these habitats were polychaete dominated, though there is a higher proportion of amphipods and bivalves than in mixed sediments. Common species included the polychaetes *Ophelia borealis, Chaetozone christiei, Spiophanes bombyx, Spio armata, Nephtys cirrosa, the amphipod Bathyporeia spp.,* and the bivalves *Abra prismatica, Cochlodesma praetenue, Moerella pygmaea and Spisula spp..* Sandeels mainly *Ammodytes spp.* were also present in a large number of these samples.

4 The infaunal samples are used to compare abundance and species richness as these were recorded using a quantitative method (grab sampling) whereas the epifaunal sampling used more qualitative methods (benthic trawls)

11.68. Epifauna and encrusting fauna (species recorded by presence / absence) were common wherever the sediment contained gravel, shell or cobble for attachment. The distribution of epifauna is related to sediment type, as would be expected, with sandy gravels and gravelly sands as a generality supporting rich epifauna, whilst slightly gravelly sands were low in epifauna. Most of the species recorded are thought to be opportunistic. For example, the majority of suitable sites supported bryozoans / hydroid turf (especially *Flustra foliacea*) and the tube worm *Hydroides norvegica*. However, the purple urchin *Echinocyamus pusillus* and the sea squirt *Ascidiella scabra* were found only at a few locations.

Sensitivity

11.69. In general, the communities present across the Project Alpha Site seem to be typical of the WSA and are representative of areas of the north sea that have been subject to fishing with ground contacting gears (such as dredges) for a number of years. As these benthic habitats have been widely impacted by fishing they are not considered to be either natural, or particularly sensitive to physical impacts.

11.70. The habitats defined by Envision Mapping Ltd (discussed previously) have also been assigned an equivalent JNCC biotope code (Table 11.6). The sensitivity of many of the marine biotopes has been determined by the Marine Life Information Network (MarLIN) both in a report (Tyler-Walters *et al.*, 2004) and on the MarLIN website. A summary of the available information on the sensitivity of the habitats found across the Project Alpha Site is provided in Table 11.8.

Table 11.8 Sensitivity of subtidal biotopes identified at the Project Alpha and Project Bravo Sites

Habitat (Envision)	Equivalent JNCC Biotope (JNCC 2012)	Value/ sensitivity	Justification (Species traits / recoverability taken from JNCC (2011) or MarLIN – references in text)
Dense *Amphiura/ Phoronis*	SS.SMu.CSaMu.AfilMysAnit	Low to Moderate	This biotope has low or no sensitivity to all relevant changes in physical factors apart from substratum loss and changes in water flow to which it has moderate sensitivity (Hill, 2008). This biotope is considered "Not sensitive" to smothering This Habitat is listed under the EC Habitats Directive and the UKBAP
Dense *Chone*	SS.SMx.OMx.(Chone)	Low	The sensitivity for this habitat is not provided by Marlin (as it does not fully fit the JNCC biotope characterisation) however the sensitivity of the JNCC biotope with most similarity SS.SMx.OMx is considered "Low" by Tyler-Walters (2004).
Epifauna/ polychaete	SS.SMx.OMx.PoVen	Low	The sensitivity of this biotope is only considered in terms of substratum loss by Marlin (Marshall,2008) to which it is considered "Not sensitive". Tyler-Walters (2004) describe this biotope as having "High recoverability" and "low sensitivity"
Faunal Turf	SMX.CMx.FluHyd	Low	The sensitivity for this habitat is not provided by Marlin (as it does not fully fit the JNCC biotope characterisation) however biotope SS.SMx.CMx.FluHyd is considered to have a "low" sensitivity and High recoverability by Tyler-Walters (2004).
Ophiothrix	SMx.CMx.OphMx	Low	The sensitivity for this habitat is not provided by Marlin (as it does not fully fit the JNCC biotope characterisation) however biotope SS. SMx.CMx.OphMx is considered to have a "low" sensitivity and High recoverability by Tyler-Walters (2004).
Polychaete/ bivalve	SS.SMx.OMx.PoVen	Low	The sensitivity of this biotope is only considered in terms of substratum loss by Marlin (Marshall, 2008a) to which it is considered "Not sensitive". Tyler-Walters (2004) rate this biotope as having "High recoverability" and "low sensitivity"
Rich polychaetes	SS.SMx.OMx.PoVen	Low	The sensitivity of this biotope is only considered in terms of substratum loss by Marlin (Marshall, 2008) to which it is considered "Not sensitive". Tyler-Walters (2004) rate this biotope as having "High recoverability" and "low sensitivity"
Sabellaria	SBR.PoR.SspiMx	Moderate	The sensitivity of this biotope is only considered in terms of substratum loss by Marlin (Marshall, 2008b) to which it is considered to have "Moderate" sensitivity. *Sabellaria* as a species is considered to have "high" sensitivity to substratum loss and displacement and a "low" sensitivity to smothering. For other relevant physical factors *Sabellaria* is considered to have low or intermediate sensitivity (Marshall 2008b).
Sparse *Chone*	SS.SMx.OMx.(Chone)	Low	The sensitivity for this habitat is not provided by Marlin (as it does not fully fit the JNCC biotope characterisation) however the sensitivity of the similar JNCC biotope SS.SMx.OMx is considered "Low" by Tyler-Walters (2004).
Sparse polychaete/ bivalve	SCS.ICS.MoeVen	Low to Moderate	This biotope has "low", "very low" or "no sensitivity" to all relevant changes in physical factors apart from substratum loss, to which it has moderate sensitivity (Hill, 2008). This biotope is considered to have a "very low" sensitivity to smothering.

Project Bravo

11.71. The Project Bravo Site is characterised by water depths ranging between 42m and 56m. The sediments across the site were characterised by Envision (see Figure 11.4), showing the western section of the site to be dominated by slightly gravelly sand, the central section by sandy gravel and the eastern section by gravelly sand. Thus, the central section of the Project Bravo Site has slightly more coarse material than the eastern and western sections. The majority of the Project Bravo Site is level or undulating with occasional linear sediment waves.

11.72. The habitats across the Project Bravo Site were also characterised by Envision (see Figure 11.5). The habitats were slightly less diverse than those seen across the Project Alpha Site with two habitats - 'Faunal Turf' and 'Ophiothrix' not present (Figure 11.5). The Project Bravo Site can be divided into western and eastern halves. The western half is a mixture of habitats that is dominated by 'rich polychaetes' 'Sabellaria' and 'epifanua with polychaetes'. The eastern half of the site is predominantly 'dense Chone' and 'rich polychaetes'.

11.73. The infauna and epifauna identified and enumerated during the benthic survey are summarised below in Table 11.9.

Table 11.9 Infauna and epifauna identified as present in the Project Bravo Site

Infauna			**Epifauna**		
Taxa	**Individuals (%)**	**Species (%)**	**Taxa**	**Individuals (%)**	**Species (%)**
Polychaeta	61.5	40.2	Crustacea	81.2	44.2
Mollusca	12.5	16.6	Echinodermata	16.5	22.1
Crustacea	7.1	22.0	Mollusca	1.8	23.4
Tunicata	6.6	1.4	Polychaeta	0.2	5.2
Echinodermata	3.5	6.3	Ascidiacea	0.1	1.3
Bryozoa	2.3	10.3	Bryozoa	0.1	1.3
Nemertea	2.4	0.3	Cniaria	0.1	2.6
Cnidaria	1.9	0.3			
Others	2.1	2.7			
Total number	**6,383**	**367**	**Total**	**13,623**	**77**

Source: IECS, Appendix G1 which can be found in ES Volume III.

11.74. Abundance of individuals in the infauna ranged from 795 (station G100) to 50 (station G118) and numbers of species ranged from 125 (station G100) to 22 (station G118). Grab sample G104 had 6,537 individuals, due to very high numbers of fish larvae and eggs, which have not been included in the above summary table (see Appendix G1 for full details of infauna and species lists). Abundance and species richness from the benthic survey are shown in Figure 11.6.

11.75. Polychaetes were the dominant group in the infauna with approximately 62% of the individuals and 40% of the species. The most abundant species of polychaetes were Chone spp. (a total of 603, with 268 being the maximum number recorded at a single station which was G112) and Sabellaria spinulosa (a total of 471 with 189 being the maximum number recorded at a single station which was G103). Molluscs were the next most numerous group, accounting for approximately 13% of individuals and approximately 17% of species. The bivalve *Cochlodesma praetenue* was the most abundant mollusc with other bivalves such

as *Abra prismatica* and *Dosinia (Asa) exoleta* also prevalent. Crustaceans accounted for 7.1% of individuals and 22% of species; the most numerous crustaceans were the *amphiopod Atylus vedlomensis* and the squat lobster *Galathea intermedia.*

11.76. Crustaceans dominated the epifauna accounting for almost 81% of individuals and 44% of species (Table 11.9). The most numerous species being the shrimps *Crangon allmani* and *Pandalina brevirostris.*

11.77. Twenty eight species of fish were also caught in the trawls the most abundant species by some margin were sandeels, mostly of the species *Ammodytes spp.*, with 981 recorded across the Project Bravo Site and 565 within a single trawl (V36).

11.78. The number of species and individuals within the Project Bravo Site is generally lower than those within the Project Alpha Site, which is likely to be a result of predominance of finer sediments in the Project Bravo Site compared to the Project Alpha Site. See a discussion on the relationship between abundance, species richness and sediment type later in this section.

11.79. This highest numbers of individuals recorded in the Project Bravo Site were in 'dense Chone' areas of gravelly sand (see Figure 11.4, Figure 11.5 and Figure 11.6). However, there are no apparent trends across the Project Bravo Site with respect to either abundance or species richness.

11.80. As in the Project Alpha Site, the more mixed sediments in the Project Bravo Site support encrusting fauna such as hydroids, bryozoans and ascidians, which in turn allow other associated fauna to survive. Common species found from this community include the polychaetes *Pholoe spp., Eulalia spp., Eumida sanguinea, Glycera lapidum, Dipolydora spp. Cirratulus cirratus, Pomatoceros triqueter, Hydroides norvegica, Ampharete lindstroemi, Polycirrus spp.*; the bivalves *Cochlodesma praetenue, Tridonta montagui, Timoclea ovata, Dosinia exoleta, Hiatella arctica*; and the *ascidian Ascidiella scabra.*

11.81. Sandier sediments have low abundance and species richness. Again these habitats are polychaete dominated, though there is a higher proportion of amphipods and bivalves. Common species found from these habitats include the polychaetes *Ophelia borealis, Chaetozone christiei, Spiophanes bombyx, Spio armata, Nephtys cirrosa,* the amphipod *Bathyporeia spp.*, and the bivalves *Abra prismatica, Cochlodesma praetenue, Moerella pygmaea* and *Spisula spp.*. Sandeel *Ammodytes spp.* is also present in many of these samples.

11.82. Epifauna and encrusting fauna (species recorded by presence / absence) were common wherever the sediment contained gravel, shell or cobble for attachment. The distribution of epifauna is related to sediment type, as would be expected, with sandy gravels and gravelly sands as a generality supporting rich epifauna, whilst slightly gravelly sands were low in epifauna. Most of the species recorded are thought to be opportunistic. For example, the majority of suitable sites supported bryozoans / hydroid turf (especially *Flustra foliacea*) and the tube worm Hydroides norvegica. However, the purple urchin *Echinocyamus pusillus* and the sea squirt *Ascidiella scabra* were found only at a few locations.

Sensitivity

11.83. In general, the communities present seem to be typical of the WSA and are representative of areas of the North Sea that have been subject to fishing with ground contacting gears (such as trawls and dredges) for a number of years. As these benthic habitats have been widely impacted by fishing, they are not considered particularly sensitive to physical impact and are thought to be able to recover from impact relatively rapidly. The sensitivity of the equivalent JNCC biotopes (as defined by Tyler-Walters, 2004) of all the habitats identified by Envision across the Project Bravo Site is provided in Table 11.8 above.

Transmission Asset Project

Infrastructure within the Project Alpha and Project Bravo Site boundaries

11.84. The OSPs and array cables which are part of the Transmission Asset Project infrastructure will be placed within the site boundaries of Project Alpha and/ or Project Bravo. The baseline environment within these areas is therefore as described in the above sections.

Export Cable Route Corridor

11.85. The final boundaries for Project Alpha and Project Bravo had not been delineated at the time of benthic surveys and therefore the ECR corridor survey area extended from landfall to the edge of the Round 3 Zone (Figure 11.1). The ECR corridor now includes an area within the Zone boundary, to the west of Project Alpha, that was included in the surveys conducted across the initial Phase 1 study area (Figure 11.2). Eight grab samples were collected from within this area and these have been used to characterise the existing environment within this part of ECR corridor. The infaunal taxa from samples located within the entire ECR corridor are presented in Table 11.10. This 11.10 is split into samples collected during the ECR survey, referred to as the western part of the ECR corridor, and samples collected in the Phase 1 survey, referred to as the eastern part of the ECR corridor.

11.86. The remainder of the ECR contained two landfall options at the time of the benthic survey; one which made landfall at Arbroath and one which made landfall at Carnoustie. As the project has developed the Arbroath landfall has been ruled out, however data was collected from the Arbroath Cable route which is helpful in characterising the wider area.

11.87. The central and western parts (results from the ECR benthic survey) of the ECR corridor were dominated by molluscs and polychaetes (Table 11.10). The key molluscs were bivalves such as *Fabulina fibula, Thyasira (Thyasira) flexuosa* and *Chamelia striatula.* The key polychaetes were *Spiophanes bombyx* and *Magelona johnstoni.* The brittle star *Amphiura filiformis* was the dominant echinoderm, with three amphipods *Harpinia antennaria, Ampelisca tenuicornis* and *Bathyporeia elegans* dominating the crustaceans. Abundance and species richness from the benthic survey are shown in Figure 11.8.

11.88. The offshore/ eastern section (results from the Phase 1 area survey) of the ECR corridor is dominated by polychaetes with significant numbers of molluscs and echinoderms present (Table 11.10). However it should be noted that due to the process of refining the cable route (post benthic survey) this data is based on only eight samples which were not positioned specifically to characterise the ECR corridor rather positioned to sample the Phase 1 part of the Round 3 zone. These samples are therefore included to simply give an indication of the species present.

11.89. The habitats across the ECR corridor can largely be divided into four sections (see Figure 11.9). As the ECR corridor leaves the Project Alpha Site it crosses 'Ophiothrix' and 'faunal turf' habitats at the eastern most end before passing through areas characterised as 'sparse polychaetes/ bivalves' and 'Sabellaria'. Moving east a mixture of 'rich polychaetes' and 'sparse Amphiura' habitat with outcrops of cobble / faunal turf habitat and 'epifauna and polychaete' habitat was found. Further inshore the ECR corridor is dominated by a large stretch of the 'Amphiura / Phoronis' habitat which gives way to cobble turf habitat close to the landfall.

Table 11.10 Infauna identified as present within the Transmission Asset Project the ECR survey and Phase 1 area survey

ECR corridor grab samples (western part, see Figure 11.3)			ECR corridor grab samples (eastern part, see Figures 11.1 and 11.2)		
Taxa	Individuals %	Species %	Taxa	Individuals %	Species %
Mollusca	38.2	18.5	Polychaeta	64.7	48.3
Polychaeta	35.9	45.7	Mollusca	9.5	14.0
Echinodermata	8.7	6.0	Echinodermata	5.8	8.7
Crustacea	5.8	17.9	Tunicata	5.7	1.2
Nemertea	1.8	0.5	Crustacea	4.6	10.5
Cnidaria	1.0	5.4	Nemertea	4.6	0.6
Bryozoa	0.3	2.2	Bryozoa	1.9	7.6
Tunicata	0.2	1.6	Cnidaria	1.6	6.4
Others	8.0	2.2	Others	1.8	2.9

Source: IECS, Appendix G1 which can be found in ES Volume III.

Landfall

11.90. In general, the intertidal area at the point at which the ECR corridor makes landfall is not species rich or habitat diverse. The landfall area is dominated by an extensive rock revetment installed along the shoreline to protect against coastal erosion. The revetment extends from the upper shore well into the mid-shore area. The greatest species richness and diversity of habitat is on the artificial substrata of the rock revetment, the occasional exposed bedrock or large pieces of washed up timber.

11.91. The sandy beach was typical of a beach exposed to high currents and wave action, with mobile sediments devoid of benthic fauna. Excavations during the walkover revealed a lack of macrofauna.

11.92. Lower eulittoral sediments were dominated by polychaetes and included sediment tidal pools. The pools did not support diverse fauna or flora, only the presence of fish and mobile species caught by the falling tide. Notably, sediments along the lower shore of these tide pools did have occasional occurrence of the sand mason worm *Lanice conchilega*. Further north, at the entrance to the discharge of Barry Burn, the sediments were densely populated by this polychaete.

11.93. The rock revetment referred to above was largely colonised by the lichens Xanthoria *parietina, Caloplaca marina* and *Verrucaria maura*, with winkles (*Littorina saxatilis* and *Melarhaphe neritoides*), limpet *Patella vulgata*, the barnacle *Semibalanus balanoides* interspersed with the mussel *Mytilus edulis*.

Sensitivity

11.94. The sensitivity of many of the marine biotopes found across the ECR has been determined by the MarLIN. A summary of the available information on the sensitivity of the habitats found across the ECR is provided in Table 11.11.

11.95. Although the ECR corridor passes through an area of habitat at its eastern end that is characterised as 'Sabellaria' habitat (according to the habitats modelled by Envision (2011) no infaunal samples containing *Sabellaria spinulosa* were collected from this area and therefore it is highly unlikely that Sabellaria is present forming dense aggregations that constitute reef as defined by Gubbay (2007).

Table 11.11 Sensitivity of subtidal biotopes identified across the Transmission Asset Project

Habitat (as identified by Envision)	Equivalent JNCC Biotope (JNCC 2012)	Value/ sensitivity	Justification (Species traits / recoverability taken from JNCC (2011) or MarLIN – references in text)
Dense *Amphiura/ Phoronis*	SS.SMu.CSaMu.AfilMysAnit	Low to Moderate	Please refer to Table 11.8
Cobble/ faunal turf	SS.SMX.CMX	Moderate	The sensitivity for this habitat is not provided by Marlin however biotope SS.SCS.CMx is considered to have a "moderate" sensitivity and "moderate" recoverability by Tyler-Walters (2004).
Epifauna/ polychaete	SS.SMx.OMx.PoVen	Low	Please refer to Table 11.8
Fabulina	SSa.IMuSa.FfabMag	Very low to Moderate	This Biotope has very low or no sensitivity to all relevant changes in physical factors apart from substratum loss and increases in water flow to which it has moderate sensitivity (Rayment, 2008). This biotope is considered to have "very low" sensitivity to smothering
Faunal Turf	SMX.CMx.FluHyd	Low	Please refer to Table 11.8
Ophiothrix	SMx.CMx.OphMx	Low	Please refer to Table 11.8
Polychaete/ bivalve	SS.SMx.OMx.PoVen	Low	Please refer to Table 11.8
Rich polychaetes	SS.SMx.OMx.PoVen	Low	Please refer to Table 11.8
Rocky/ Faunal Turf	None assigned	Moderate	This habitat was not ground truthed using video sampling as the survey vessel was not able to manoeuvre in the shallow water where this habitat is present. This habitat has been identified using the geophysical data only. Taking a precautionary approach this habitat has been assigned a moderate sensitivity.
Sabellaria	SBR.PoR.SspiMx	Moderate	Please refer to Table 11.8
Sparse *Amphiura*	SMx.CMx.MysThyMx	Low to Moderate	This biotope has low to moderate sensitivity to a number of physical factors (Marshall, 2008c). Those which are considered to be of Moderate sensitivity include substratum loss, increased flow rate, decreased flow rate, increase in wave exposure, and decrease in wave exposure. Note: this habitat is not judged to be sensitive to smothering

Habitat (as identified by Envision)	Equivalent JNCC Biotope (JNCC 2012)	Value/ sensitivity	Justification (Species traits / recoverability taken from JNCC (2011) or MarLIN – references in text)
Sparse polychaete/ bivalve	SCS.ICS.MoeVen	Low to Moderate	Please refer to Table 11.8
Thyasira	SS.SCS.CMx	Moderate	The sensitivity for this habitat is not provided by Marlin however biotope SS.SCS.CMx is considered to have a "moderate" sensitivity and "moderate" recoverability by Tyler-Walters (2004).

Notable Features within the ISA

11.96. Notable features across the ISA are described below and include species or habitats of particular ecological interest identified during the surveys. In addition, the potential for habitats of conservation value to be present is also noted.

Designated Sites, PMFs and Potential Annex 1 Features

11.97. Marine Scotland is leading a process to identify and designate Marine Protected Areas (MPAs) in Scottish waters to contribute to an ecologically coherent network of MPAs throughout the United Kingdom (UK) (see Chapter 9: Nature Conservation Designations Section 9.7) (Marine Scotland,2011). This process is still in the early stages, but at the time of writing (July 2012) the Project Alpha and Project Bravo Sites potentially contain one Priority Marine Feature (PMF) habitat one PMF species and one 'large scale feature' which will be the basis upon which sites are put forward for designation. The designation of sites is expected in 2012. The features which are found within the ISA are:

- offshore subtidal sands and gravels (PMF habitat);
- ocean quahog *Arctica islandica* (PMF species); and
- shelf banks and mounds (large scale feature).

11.98. It should be noted that sandeels are a PMF and areas in the Firth of Forth have been identified as important sandeel locations (JNCC *et. al.*, 2012); however, none overlap with the ISA. For further information please refer to Chapter 9: Nature Conservation Designations.

11.99. At present MPAs have not been designated for these features; however, there are areas of search for these features, which are shown in relation to the ISA in Figure 11.10. Until such time when the MPAs are proposed, with potential boundaries and features, it is not possible to assess the potential impacts to these features and therefore they are not considered within this impact assessment (Sections 11.6 to 11.9).

11.100. At the landfall end of the ECR corridor a very small overlap with an area of potential Annex I reef may exist. This is composed of subtidal rocky reef (Figure 11.11). At present there are no plans to designate this area and no evidence of rocky reef was found during the geophysical surveys in this area (As presented in Chapter 7: Physical Environment).

11.101. No other areas that could qualify as Annex I habitat are within the ISA.

11.102. There are no sites currently designated for Benthic features within the Alpha or Bravo sites and therefore the effects of the two wind farms on Benthic ecology are not discussed further within this chapter (Further information is however is provided in Chapter 9: Nature Conservation Designations). The Export cable landfall site does overlap with the Barry Links SAC and SSSI neither of which are designated for Benthic or intertidal features and therefore are these designations are not considered further in this chapter. The Firth of Tay & Eden Estuary SAC also overlaps with the export cable corridor, this SAC is primarily designated for "Estuaries", but also has as a qualifying feature, but not a primary reason for selection "Intertidal mudflats and sandflats" (JNCC, undated). The potential for the Transmission Asset Project to affect this SAC is discussed in Section 11.6 Transmission Asset Project.

Sabellaria spinulosa

11.103. Ross worm *Sabellaria spinulosa* is a common tube-building polychaete which can form dense aggregations on mixed or rocky substrates. *S. spinulosa* often forms crusts, which in many cases are temporary features that break up in autumn / winter storms (Gubbay, 2007 and Limpenny *et al.*, 2010).

11.104. The species can also occur in reef form, at which point it is considered of higher ecological importance as a biogenic reef under the Annex I Reef Description under the Habitats Directive. This type of biogenic reef is considered a threatened and declining habitat by OSPAR (OSPAR Commission, 2008).

11.105. If aggregated as a reef or crust, the species is considered to be sensitive to substratum loss and physical damage or displacement. The worms are fixed to the substratum and cannot reattach once dislodged and cannot rebuild their tubes if removed from them. The species is tolerant of water quality changes and increases in turbidity (Jackson & Hiscock, 2008).

11.106. The species was found within Project Alpha, Project Bravo and in the ECR corridors (Figure 11.12). The grab sampling program identified *Sabellaria spinulosa* as present at 5 stations within Project Alpha, 14 stations within Project Bravo and no stations within the ECR. Only one sample station within Project Alpha and four stations within Project Bravo contained more than 10 individuals. The post survey video analysis did locate possible Sabellaria tubes at two locations within the Project Alpha and two locations within Project Bravo (Figure 11.12); however, these were estimated to cover less than 10% of the area sampled and would not be considered as either a crust or reef under the criteria developed by Gubbay (2007).

11.107. Given that no aggregations of *Sabellaria spinulosa* have been located within the ISA, and that this species is common, with individuals tolerant of both disturbance and water quality changes, the species is not a major concern with regard to potential impacts of the construction, operation and decommissioning of the Seagreen Project.

Arctica islandica

11.108. Ocean quahog *Arctica islandica*, is a long lived bivalve that is considered to be a 'threatened or declining species' by OSPAR (OSPAR Commission, 2008) and is a potential qualifying feature for MPAs as a PMF under the Scottish MPA process (Marine Scotland, 2011).

11.109. *Arctica islandica* was recorded at 22 sites across the ISA (Figure 11.13), however, only juveniles were found, with a maximum abundance of four specimens per $0.1m^2$ grab sample. The presence of only juveniles on such an extensive survey indicates an on-going source of disturbance, which has prevented the species from maturing more widely across the area. The quahog is a long lived and slow growing species, potentially thought to live

for many hundreds of years (Schöne *et al.*, 2005) and in the absence of external factors such as disturbance, suitable habitat would be expected to support a range of year classes, showing a normal distribution by age. The presence, only of juveniles, suggests that more mature animals may have been removed by external disturbance mechanisms over a period of many years. The main activity causing seabed disturbance within the site is commercial fishing, in particular with seabed operating mobile gear such as trawls and dredges.

Modiolus modiolus

11.110. The horse mussel *Modiolus modiolus* forms dense beds, at depths up to 70m (but may extend onto the lower shore). Although the horse mussel is a widespread and common species, horse mussel beds (with typically 30% cover or more) are more limited in their distribution and as a result, horse mussel beds are considered to be a 'threatened and/ or declining habitat' by OSPAR (OSPAR Commission, 2008). They are listed as a habitat of conservation importance in the PMFs for Scottish territorial waters (Marine Scotland 2011).

11.111. Single *Modiolus modiolus* individuals were recorded within both the Project Alpha and Project Bravo Sites during the grab sampling survey (G83 and G103) with a further two individuals identified within Project Bravo (V48) during the trawl surveys (Figure 11.14). There was no evidence of *Modiolus modiolus* beds recorded within the survey area.

Capitella capitata

11.112. One sample (G76), located within the Project Alpha Site, contained an elevated number (592 individuals) of the polychaete *Capitella capitata*. This is an opportunistic species tolerant of stressful conditions, often found in polluted waters (for example due to sewage discharges or elevated levels of hydrocarbons or metals) where it out-competes less tolerant species. A large abundance of *Capitella capitata* could indicate polluted water or sediment (Clark, 1997), however, it is not known why the elevated numbers occurred at this one location as there is no obvious source of pollution. The species was found at four other stations in the low numbers expected if found in non-polluted sediments (Figure 11.15).

Ammodytes (Sandeels)

11.113. The outer Firth of Forth and northwest North Sea have long been known to support important sandeel populations. The highest density of this population is focused on the Wee Bankie, some 30km south of the Seagreen Project; however, sandeels range across much of the wider and immediate study areas. Sandeels spend much of their life cycle within the sediment and therefore impacts on benthic ecology have the potential also to affect them. For the purposes of this assessment information regarding sandeels and the potential impacts associated with the proposed development are discussed in Chapter 12 Natural Fish and Shellfish Resource.

Scallops

11.114. Two species of scallop *Pectin maximus* and *Aequipecten opercularis* were present within benthos across the ISA. The assessment of impacts to these species is considered in Chapter 12: Natural Fish and Shellfish Resource and Chapter 14: Commercial Fisheries.

ASSESSMENT OF IMPACTS – WORST CASE SCENARIO

11.115. For the purpose of the benthic and intertidal ecology impact assessment, the worst case scenario, taking into consideration the options currently being assessed, is summarised in Tables 11.12a to 11.12c and are detailed further in Appendix G4 which can be found in ES Volume III.

11.116. For benthic and intertidal ecology the worst case scenario will comprise the design options that provide the maximum area of directly and indirectly affected seabed. Establishing the worst case scenario from the range of design options under consideration (see Chapter 5: Project Description) ensures that the assessment is focused on the maximum potential adverse impact that could arise from the development. Only those development parameters that are considered to have a material bearing on the impact under consideration are identified within Tables 11.12a-c.

11.117. The worst case scenarios for the Transmission Asset Project are defined in detail in Appendix G4 and briefly summarised in Table 11.12c. The Offshore Substation Platforms (OSPs) have been considered only within the detailed assessments for Project Alpha and Project Bravo respectively. The outcome of the OSP assessments is then cross referenced where appropriate when describing the potential effects of the Transmission Asset Project. For details of the Project components contained within the worst cases refer to Appendix G4.

11.118. The worst case scenarios identified below are also applied to the assessment of cumulative impacts. In the event that the worst case scenarios for the project in isolation do not result in the worst case for cumulative impacts, this is addressed within the cumulative assessment section of the Chapter (see Cumulative Assessment section of this chapter).

Table 11.12 a Worst case scenario for Project Alpha assessment (includes WTGs, array cables and ancillary structures and any activities to place maintain or remove these). Further detail is provided in Appendix G4 which can be found in ES Volume III.

Effect	Worst case scenario	Justification
Construction		
Direct impact on benthos due to physical disturbance	The worst case scenario is that the maximum possible area of disturbance of the seabed occurs in the most sensitive habitats. The maximum area of disturbance is calculated as 375.27ha (see Table 1 in Appendix G4 which can be found in ES Volume III, for detail)	The worst case scenario is established by defining the maximum amount (spatial extent) of habitat disturbance that Project Alpha could have – this is the footprint of infrastructure (substructure/foundations and cables) plus any disturbance due to the footprint of plant (e.g. jack-up vessels and ROVs)
Direct impact on benthos due to the permanent loss of habitat	The worst case scenario is that the maximum possible area of habitat loss occurs in the most sensitive habitats. The maximum area of habitat loss is 88.80ha which is comprised of the: array cable protection, The WTG GBS, meteorological masts and Offshore substation platforms (OSP)s . (see Table 1 in Appendix G4 which can be found in ES Volume III, for detail)	The loss of subtidal habitat will result from the placement of built structures (and associated scour protection material) on the seabed. The worst case scenario is therefore, represented by the largest permanent footprint off all structures place on the seabed.
Increased suspended sediments and mobilisation of contaminants leading to smothering	The worst case scenario would result in the maximum amount of sediment being released in the shortest time. The greater the amount of sediment released the higher the potential for contaminant release. The greatest possible amount of material release will be 2,932,200m3 which could occur over a maximum 36 month period (see Table 1 in Appendix G4 which can be found in ES Volume III, for detail).	The worst case' scenario is represented by that which could result in the maximum volume of sediment arising (and therefore, maximum volume of material that could potentially be brought into suspension).
Operation		
Direct impact on benthos due to physical disturbance caused by maintenance activities	The worst case scenario is will result from the maximum foreseeable amount of maintenance activity which has the potential to cause disturbance to the seabed.	Maintenance activity may impact on benthos if the plant used interacts with the seabed. The scenario therefore, provides for the maximum level of seabed disturbance from jack-up vessels. Use of Dynamic Positioning (DP) vessels would not have an impact on the subtidal habitat.
Indirect impacts on benthos from changes in current regime resulting in habitat loss	The maximum area of habitat loss will occur if the greatest possible numbers of structures are placed on the seabed without the use of any scour protection. This will result in an area of 35.61ha of habitat loss (see Table 1 in Appendix G4 which can be found in ES Volume III, for detail)	The worst case scenario for habitat loss during operation will occur if no scour protection is deployed around the foundations of the offshore structures. The ensuing scour will result in the habitat surrounding each installation to be lost. The worst case scenario for habitat loss during operation as a result of ancillary structures would be option 1, as presented in Chapter 5 Project Description, which would result in 3 substations within the Alpha Site in the worst case scenario these would have GBS foundations.

Effect	Worst case scenario	Justification
Increased suspended sediments and mobilisation of contaminants leading to smothering of benthic ecology	The worst case scenario would result in the maximum amount of sediment being released in the shortest time. The greater the amount of sediment released the higher the potential for contaminant release. The greatest amount of material release is predicted to be 345,522m3. (see Table 1 in Appendix G4 which can be found in ES Volume III, for detail)	The worst case scenario for scour formation assumes no scour protection is provided for any offshore structure and scour occurs during a 1 in 50 year storm condition.
Alteration of habitats (colonisation of structures)	The worst case scenario for the area created/ habitat created will be approximately the same as the worst case scenario for the area of habitat loss. (88.80ha)	Aligned with seabed footprint (see loss of habitat in construction phase). The scenario provides for the maximum available surface area for colonisation, any other scenario will result in a lower surface area.
Decomissioning		
Impact on subtidal habitat	Removal of all cabling and build structures (based on worst case assumptions detailed under construction).	Arrangements associated with decommissioning will be determined prior to construction and a full Decommissioning Plan for the project will be drawn up and agreed with Marine Scotland. Until the arrangements have been clarified, the worst case scenario is that all structures will be removed.

Table 11.12b Worst case scenario for Project Bravo assessment (includes WTGs, array cables and ancillary structures and any activities to place maintain or remove these) Further detail is provided in Appendix G4 which can be found in *ES Volume III*.

Effect	Worst case scenario	Justification
Construction		
Direct impact on benthos due to physical disturbance	The worst case scenario is that the maximum possible area of disturbance occurs in the most sensitive habitats. The maximum area of disturbance is calculated as 374.84ha and is comprised of the: array cables, the WTG GBS, met masts and substations (see Appendix G4 Table 2 for detail)	The worst case scenario is established by defining the maximum amount (spatial extent) of habitat disturbance that Project Alpha could have. – this is the footprint of infrastructure (substructure/foundations and cables) plus any disturbance due to the footprint of plant (e.g. jack-up vessels and ROVs)
Direct impact on benthos due to the loss of habitat	The worst case scenario is that the maximum possible area of habitat loss occurs in the most sensitive habitats. The maximum area of habitat loss is calculated as 87.71 and is comprised of the: array cable protection, The WTG GBS, met masts and substations. (see Table 2 in Appendix G4 which can be found in ES Volume III, for detail)	The loss of subtidal habitat will result from the placement of built structures (and associated scour protection material) on the seabed. The worst case scenario is therefore, represented by the largest permanent footprint off all structures place on the seabed.
Increased suspended sediments and mobilisation of contaminants leading to smothering	As for Project Alpha, except only 2 OSP and therefore the total material released is 2,894,700m^3. (see Table 2 in Appendix G4 which can be found in ES Volume III, for detail)	As for Project Alpha, except only 2 OSP
Operation		
Direct impact on benthos due to physical disturbance	The maximum area of habitat loss will occur if the greatest possible numbers of structures are placed on the seabed without the use of any scour protection. This will result in an area of 35.42ha of habitat loss (see Table 2 in Appendix G4 which can be found in ES Volume III, for detail)	As for Project Alpha but with 2 OSPs
Indirect impacts on benthos from changes in current regime resulting in habitat loss	As for Project Alpha	As for Project Alpha
Increased suspended sediments and mobilisation of contaminants leading to smothering of benthic ecology	The worst case scenario would result in the maximum amount of sediment being released in the shortest time. The greater the amount of sediment released the higher the potential for contaminant release. The greatest amount of material release is predicted to be 341,490m^3. (see Table 1 in Appendix G4 which can be found in ES Volume III, for detail)	As for Project Alpha, except only 2 OSP

Effect	Worst case scenario	Justification
Creation of new habitats (colonisation of structures)	The worst case scenario for the area created habitat created will be approximately the same as the worst case scenario for the area of habitat loss. This was calculated as 87.71ha see Direct impact on benthos due to the loss of habitat in line 2 of this table. (see Table 2 in Appendix G4 which can be found in ES Volume III, for detail)	Aligned with seabed footprint (see loss of habitat in construction phase). The scenario provides for the maximum available surface area for colonisation, any other scenario will result in a lower surface area. Note: The eventual increase in area available for colonisation by benthic species will be greater than this due to the three dimensional nature of the structures, however a calculating this precise area would be complex and unlikely to lead to a realistic outcome.
Decommissioning		
Physical impact on subtidal habitat	Removal of all cabling and build structures (based on worst case assumptions detailed under construction).	Arrangements associated with decommissioning will be determined prior to construction and a full Decommissioning Plan for the project will be drawn up and agreed with Marine Scotland. Until the arrangements have been clarified, the worst case scenario is that all structures will be removed.

Table 11.12c Worst case scenario for Transmission Asset Project assessment (Includes ancillary structures within Alpha and Bravo and ECR) Further detail is provided in Appendix G4 which can be found in *ES Volume III*.

Effect	Worst case scenario	Justification
Construction		
Direct impact on benthos due to physical disturbance	The worst case scenario is that the maximum possible area of disturbance occurs in the most sensitive habitats. Infrastructure within the Project Alpha and Project Bravo Site boundaries (Assessed as part of Alpha and Bravo) The maximum area of disturbance of OSPs within Alpha and Bravo (and therefore assessed within the relevant sections) is 1.27ha. (see Table 3 in Appendix G4 which can be found in ES Volume III for detail) ECR corridor The maximum area of disturbance is 796.27ha (see Table 3 in Appendix G4 which can be found in ES Volume III for detail)	The worst case scenario is established by defining the maximum amount (spatial extent) of habitat disturbance that Transmission Asset Project could have.
Direct impact on benthos due to the loss of habitat	Infrastructure within the Project Alpha and Project Bravo Site boundaries (Assessed as part of Alpha and Bravo) The worst case scenario is that the maximum possible area of habitat loss occurs in the most sensitive habitats. The maximum area of habitat loss is 4.8ha. (see Appendix G4 Table 3 for detail) ECR corridor The worst case scenario is that the maximum possible area of habitat loss occurs in the most sensitive habitats. The maximum possible area of habitat loss occurs in scenario 4 and is be 41.9ha (see Table 3 in Appendix G4 which can be found in ES Volume III for detail)	The worst case scenario is established by defining the maximum amount (spatial extent) of habitat disturbance that the Transmission Asset Project could have. It has been estimated that up to 10% of the total length of the total Export cable length may be protected with either rock or mattresses. As the total maximum length of export cables is calculated to be 530km long the amount that may be protected on the seabed will be 53km in length and the protection will be up to 7m wide.
Increased suspended sediments and mobilisation of contaminants leading to smothering of subtidal habitats and species	The worst case scenario is that the maximum amount of sediment being released in the shortest time. The greater the amount of sediment released the higher the potential for contaminant release. Infrastructure within the Project Alpha and Project Bravo Site boundaries (Assessed as part of Alpha and Bravo) The greatest amount of material release is predicted to be 69,500m3 which could be released over a 36 month period ECR corridor The greatest amount of material release is predicted to be 4,770,000m3 which could be released over a 24 month period. (see Table 3 in Appendix G4 which can be found in ES Volume III,for detail)	The 'worst case' scenario is represented by that which could result in the maximum volume of arisings (and therefore, maximum volume of material that could potentially be brought into suspension).

Effect	Worst case scenario	Justification
Direct impact on intertidal ecology due to physical disturbance	Surface disturbance from vehicles associated with the works at the exit point of the borehole.	The Export cables will cross the intertidal by being installed in a borehole which will be drilled underneath the shore. Access by small lightweight vehicles may be required at the exit point of the borehole.
Operation		
Increased suspended sediments and mobilisation of contaminants leading to smothering of benthic ecology	Infrastructure within the Project Alpha and Project Bravo Site boundaries (Assessed as part of Alpha and Bravo) The worst case scenario is that the greatest amount of sediment is released over the shortest possible period of time. Conical GBS foundations with no scour protection could result in a total scour volume of 6,420m^3.	Assumes that no scour protection is provided. Conical GBS causes greatest scour areas of all foundation types during a 1 in 50 year storm condition due to combined wave and current action. Assumes the presence of up to 1 OSP on rectangular (100m x 75m) GBS and up to 4 OSPs on square (40m x 40m) GBS
Direct impacts on benthos due to habitat disturbance/loss	The worst case scenario is represented by the greatest amount of habitat that can be disturbed or lost through the formation of scour around the OSP foundation base. This is calculated to be an area of 0.39ha	Assumes that no scour protection is provided. Conical GBS causes greatest scour areas of all foundation types during a 1 in 50 year storm condition due to combined wave and current action. Assumes the presence of up to 1 OSP on rectangular (100m x 75m) GBS and up to 4 OSPs on square (40m x 40m) GBS
Direct impacts on intertidal ecology due to maintenance activities	Unplanned maintenance operations requiring vehicular plant access to the buried cable during low water. Maximum potential area of disturbance would be as specified for construction phase.	Any maintenance activity required on the intertidal section of the export cables could require vehicular access. The worst case area of impact is therefore in line with that provided for under construction.
Indirect impacts from alteration to human activities	Safety zones of 50m during operation and 500m during maintenance around the ancillary structures will be applied for. A maximum of five ancillary structures are proposed within the Transmission Asset Project	Maximum area from which other human activities will be excluded is a temporary safety zone of 500m around substations and a permanent safety zone of 50m.
Creation of new habitats (colonisation of structures)	The scenario which will create the greatest area new habitat will be approximately the same as the worst case scenario for the area of habitat loss. This was calculated as 4.8ha for the infrastructure with Alpha and Bravo and 37.1ha within the ECR see Direct impact on benthos due to the loss of habitat in line 2 of this table.	Aligned with seabed footprint (see loss of habitat in construction phase). The scenario provides for the maximum available surface area for colonisation, any other scenario will result in a lower surface area. Note: The eventual increase in area available for colonisation by benthic species will be greater than this due to the three dimensional nature of the structures, however an calculating this precise area would be complex and unlikely to lead to a realistic outcome.

Effect	Worst case scenario	Justification
Decommissioning		
Impact on intertidal ecology	Removal of six export cables.	Arrangements associated with decommissioning will be determined prior to construction and a full Decommissioning Plan for the project will be drawn up and agreed with Marine Scotland. Until the arrangements have been clarified, the worst case scenario is that all structures will be removed.
Impact on subtidal habitat	Removal of all cabling and build structures (based on worst case assumptions detailed under construction).	Arrangements associated with decommissioning will be determined prior to construction and a full Decommissioning Plan for the project will be drawn up and agreed with Marine Scotland. Until the arrangements have been clarified, the worst case scenario is that all structures will be removed.

IMPACT ASSESSMENT – CONSTRUCTION PHASE

11.119. This section assesses potential impacts during construction of the Seagreen Project.

Project Alpha

Direct impact on benthos due to physical disturbance

11.120. The installation of the wind farm components and infrastructure (including array cables, foundations, WTG, ancillary structures and meteorological masts) via jack-up barges, ploughs and cable protection will result in the temporary disturbance to the benthos.

11.121. The maximum potential area of disturbance has been calculated as 375.27ha and a breakdown of how this was carried out is summarised in Table 11.11 above, the detailed calculations are presented in Appendix G4 which can be found in ES Volume III. This equates to 1.9% of the 19,716ha Project Alpha. Physical disturbance will constitute displacement of sediment and damage or loss of communities within the area of disturbance (Table 11.12a).

11.122. In terms of the impacts on the different habitat types mapped by Envision (Figure 11.5), the worst case scenario would be that all components and infrastructure in Project Alpha would be built within the most sensitive habitat type. Table 11.8 above summarises the sensitivity of the habitats across the Project Alpha Site and Table 11.13 below provides calculations of the area of disturbance of Project Alpha in regards to the ISA and Project Alpha Site. The most sensitive habitat is *Sabellaria* (equivalent biotope SBR.PoR.SspiMx), which has been defined as having moderate sensitivity. It is necessary to consider this impact in the context of the known resource of that habitat derived from survey data, with the maximum potential area of disturbance due to Project Alpha (375.27ha) being shown to be 3.3% of the entire area of ISA that was identified as being *Sabellaria* habitat (Table 11.13).

11.123. As the final method of array cable installation is yet to be chosen (as presented in Chapter 5: Project Description in this ES) it is not possible to assess the exact impacts of the installation on the benthos, however, it is likely that there will be some degree of disturbance as a result of this activity. Given that the works would be temporary the magnitude is considered to be low. Monitoring at the Kentish Flats Offshore Wind Farm which was constructed on similar North Sea sandy habitats has showed no evidence of significant seabed change caused by the cable installation (EMU, 2008).

11.124. Jack-up barge legs could be expected to create depressions in the seabed of up to 2m (as presented in Chapter 5: Project Description). Following construction, these depressions will be likely to back-fill naturally over time. For example, at Kentish Flats the smaller depressions have been observed to back-fill by an average of 0.2m over six months in similar types of sediments (Emu, 2006). Damage will occur to the infauna and epifauna within the footprint of the jack-up barge legs through compaction of the sediment.

11.125. Although *Sabellaria spinulosa* individuals were identified across the Project Alpha Site during the benthic survey and a habitat was characterised by Envision as *Sabellaria* (Appendix G2 which can be found in ES Volume III), no dense aggregations or reefs (as defined by Gubbay, 2007) were recorded.

Table 11.13 Areas of disturbance and habitat loss at the Project Alpha Site

Habitat (Envision)	Alpha Site		ISA (extent of characterised benthic habitats)	
	Size of disturbed area within Project Alpha (ha)	% of total Project Alpha Site disturbed	Maximum Area of Habitat Loss as a % of Habitat within ISA.*	Area of disturbance as a % of Habitat within the ISA
Dense *Amphiura/ Phoronis*	543	2.8	2.2	9.3
Dense *Chone*	2945	14.9	0.7	3.1
Epifauna/ polychaete	65	0.3	2.6	10.9
Faunal turf	1717	8.7	2.4	10.0
Ophiothrix	132	0.7	7.7	32.6
Polychaete/ bivalve	2278	11.6	1.8	7.8
Rich polychaetes	585	3.0	1.0	4.2
Sabellaria	3937	20.0	0.8	3.3
Sparse *Chone*	3936	20.0	1.6	6.7
Sparse polychaete/ bivalve	3576	18.1	0.9	3.8

*In the worst case scenario the entire Project Alpha would be built in one single habitat, therefore this calculation is of the area of each habitat that would be lost if this theoretical scenario occurred.

11.126. Only one habitat identified within the Project Alpha Site is listed under the EC Habitats Directive and the UK Biodiversity Action Plan (Hill 2008). However, dense *Amphiura / Phoronis* (equivalent JNCC biotope SS.SMu.CSaMu.AfilMysAnit) is considered not sensitive to smothering or increase in suspended sediments (the most relevant causes of physical disturbance) and therefore the sensitivity of this receptor is low. This habitat is only located in the extreme south west of the Project Alpha Site (Figure 11.5) and, although if the entire Project Alpha was to be built within this habitat it would disturb up to a maximum of 9.3% of the habitat identified within the ISA, it is not feasible to locate the entire project within this small area and therefore the actual area potentially affected will be considerably less.

11.127. The majority of subtidal species and biotopes identified at the site (Table 11.8) exhibit good potential to recover after construction, particularly from localised and short term disturbance. It is anticipated that the benthic community impacted during construction will recover to pre-impact levels and species richness following construction, with re-establishment boosted following subsequent spawning and recruitment periods and monitoring studies at operational wind farms support this conclusion. At the Kentish Flats Offshore Wind Farm, post-construction benthic monitoring showed that any changes in the benthos since the pre-construction baseline were indistinguishable from what would be expected due to natural change (Vattenfall, 2008). Likewise studies at the Egmond aan Zee wind farm in The Netherlands comparing the macrofauna inside the wind farm with six reference areas showed that there were no major differences a few months after completion of the wind farm (Daan *et al.*, 2009). Some more disturbed areas may be slower to recover than others, for example, within the jack-up depressions or along the cable route, but it is anticipated that all areas will recover over time.

11.128. Given that only a small proportion (1.9%) of seabed within the Project Alpha Site will be affected and that even if the entire wind farm was located within the most sensitive habitat (*Sabellaria*) it would only disturb a maximum of 3.3% of the area of that habitat known to occur within the ISA, the magnitude of the impact will be low. The species and habitats will recover quickly following construction, are widespread within the area and the single habitat of conservation concern has been identified as not sensitive to the effects of disturbance as a result of construction of Project Alpha; therefore they are of low sensitivity. It is considered, therefore that the impact of direct physical disturbance of subtidal benthic species and habitats during construction will be negligible and **not significant**. As site specific data has been collected using a range of techniques the confidence in this assessment is considered high.

11.129. If *Sabellaria* were present in its reef form, this would be of higher sensitivity than the other habitats found within the Project Alpha Site and consequential adverse impacts would potentially have greater significance. However, no *Sabellaria* reef is believed to be present at the site, although, pre-construction survey will be used to confirm this if construction is planned in an area of *Sabellaria* habitat.

Mitigation

11.130. The following mitigation measures will be adopted by Seagreen

Mitigation

Siting of WTGs, array cables and ancillary structures to avoid the areas of more sensitive habitats (Dense *Amphiura/Phoronis* and *Sabellaria* Figure 11.5) wherever practicable.

As part of the pre-construction survey (which will be agreed with Marine Scotland) data will be analysed to ascertain the presences of any rare or important habitats, such as biogenic *Sabellaria* or *Modiolus* reef; and

If pre-construction surveys were to identify any areas that are considered to constitute biogenic reef, micrositing of WTGs, ancillary infrastructure and cables, and subsequent consultation with Marine Scotland to ensure that planned installation would not have a significant adverse effect on these features.

Residual Impact

11.131. With these mitigation measures in place the magnitude of the impact will be reduced but will remain negligible and **not significant**.

Direct impact on benthos due to the loss of habitat

11.132. The positioning of structures on the seabed as part of the construction of Project Alpha will result in long term loss of seabed and associated habitats and fauna within the footprint of the structures, for the life of the scheme (circa 25 years).

11.133. The worst case build scenario has been detailed in Table 11.12a, which identifies the structures which will result in seabed take as: WTG foundations and associated scour protection, ancillary structures, cable protection and meteorological masts. The maximum loss of seabed is anticipated to be 1.13km^2 (see Table 1 in Appendix G4 which can be found in ES Volume III, for a breakdown of the different components). The total area affected will constitute 0.57% of the total consent area (197km^2). The majority of seabed lost will be as a result of the WTG foundations and associated scour protection.

11.134. Any reduction from the worst case in terms of materials required on the seabed will reduce the area of habitat loss. The biotopes present across the Project Alpha Site are discussed in

Section 11.4. Table 11.8 summarises these biotopes and assesses their value and sensitivity and Table 11.13 provides calculations of the potential area of habitat loss and the area in of ISA and Project Alpha Site that this represents.

11.135. As discussed in paragraphs 11.118 to 11.129 above, the and in Table 11.12a the worst case scenario would be that the entire Project Alpha would be located within the most sensitive habitat which has been identified as the *Sabellaria* habitat (Table 11.8). If this unlikely scenario is realised then 112.99ha of the *Sabellaria* habitat could be lost. However this represents less than 1% of the *Sabellaria* habitat known to occur within the ISA.

11.136. Only one habitat identified within the Project Alpha Site is listed under the EC Habitats Directive and the UK Biodiversity Action Plan (Hill 2008). Dense *Amphiura/ Phoronis* (equivalent biotope SS.SMu.CSaMu.AfilMysAnit) is considered to have 'moderate' sensitivity to substratum loss (the most relevant physical factor associated with this impact) (Hill, 2008) and therefore the sensitivity of this receptor is medium. This habitat is only located in the extreme south west of the Project Alpha Site (Figure 11.5) and if all of Project Alpha was constructed within this habitat it would result in the loss of 2.8% of total amount of this habitat known to occur within the ISA.

11.137. Although the *Sabellaria spinulosa* individuals were identified at the site through the benthic survey and a habitat was characterised by Envision as "*Sabellaria*" (Appendix G2 which can be found in ES Volume III) there were, no dense aggregations or reefs (as defined by Gubbay, 2007) recorded within the site boundary.

11.138. Given that the area of habitat loss represented by building Project Alpha will be relatively small in relation to the ISA the magnitude of the impact is considered to be low. However given that this impact will be permanent (for the life of the project and in using the worst case scenario the sensitivity of the habitats to substratum loss (which will occur as a result of this impact) is considered to be medium. Therefore in accordance with Table 11.5 the direct impact on benthos due to the loss of habitat is considered to be minor adverse and **not significant**.

11.139. In this instance the use of the worst case scenario approach has led to an assessment on an exaggerated impact (as it is very unlikely that the whole footprint of Project Alpha would be within the *Amphiura/ Phoronis* habitat.

11.140. Given that site specific data have been collected using a range of techniques for this assessment, there is a high degree of confidence that the resulting impacts of construction will not exceed those predicted.

Mitigation

Mitigation

Siting of infrastructure to avoid the areas of sensitive habitat (Dense *Amphiura/ Phoronis* and *Sabellaria* Figure 11.5) wherever practicable.

As part of the pre-construction survey (which will be agreed with Marine Scotland) data will be analysed to ascertain the presences of any rare or important habitats, such as biogenic *Sabellaria* or *Modiolus* reefs; and

Micrositing of WTGs and other infrastructure, if pre-construction surveys were to identify any areas that are considered to constitute for example biogenic reef consultation with Marine Scotland to ensure that planned installation would not have a significant adverse effect on any reef features.

Residual Impact

11.141. With these mitigation measures in place the magnitude of the impact will be reduced but will remain negligible and **not significant**.

Indirect impacts on benthos due to increased suspended sediments

11.142. Increased suspended sediment load has the potential to impact on benthic species through blockage to the sensitive filter feeding apparatus of certain species and / or smothering of sessile species upon deposition of the sediment. Chapter 7: Physical Environment identifies the two main construction activities within Project Alpha that will increase suspended sediment concentration (SSC), which are installation of GBS foundations and the installation of the array cables. The activities which could lead to increased SSC and subsequent elevated sedimentation will occur intermittently over the maximum three year construction window (as presented in Chapter 5: Project Description and the levels of anticipated increase in suspended sediment caused by the construction of Project Alpha are detailed in Chapter 7: Physical Environment.

GBS foundation installation

11.143. Prior to installation of the GBS foundations for the WTG and the OSPs the sea bed will be prepared by excavating a maximum total of 642,200m^3 (Table 1 in Appendix G4 which can be found in ES Volume III) of material (this figure includes the combined amount from all GBSs). This material will either be side-cast or if removed using a suction dredge may be dispersed from the vessel operating the dredge.

11.144. Sediment which has been side-cast will remain on the sea bed during neap tides and start to become mobilised and dispersed during spring tides and storm events. Material released from the suction dredger (if used), will mostly fall to the seabed as part of a dynamic plume[5] or a passive plume[6]. Any material released as a passive plume will be in low concentrations and remain for a relatively short duration, becoming widely dispersed in the area of tidal currents.

11.145. Once material is returned to the seabed from the dynamic plume (if a cutter suction dredger is used) or is side cast directly onto the seabed, it will remain in situ until the shear stresses acting on the sediment grains exceeds the threshold for motion of that particular grain size, whereupon sediment mobilisation will become initiated. The shear stresses are caused by tidal and wave-induced currents

11.146. Whilst the overall total of potentially released sediments is high, this will take place on a foundation by foundation basis over the course of the build period, with a maximum of two foundations being installed at any one time. The dispersal of sediment is likely to occur along the main axis of tidal current flow (NNE to SSW) with elevated sediment concentrations being relatively low compared to background values, and of a short-term duration (as presented in Chapter 7: Physical Environment). The assessment of the effects of GBS installation on suspended sediment concentrations and transport within Chapter 7 concluded that the magnitude of the impact of GBS ground preparation on suspended sediment levels would be of low magnitude regardless of which method (suction dredge or side-cast) is used (Chapter 7: Physical Environment).

5 A dynamic plume is influenced by the rapid downward mode of release from the dredger, typically resulting in deposition of the vast majority of the material within a few hundred metres of the activity.

6 Is a smaller plume than the dynamic plume containing sediment which is either stripped from the dynamic plume or re-suspended from the seabed, but can have an influence over a wider seabed area as tidal currents transport the material further away until it settles.

Array Cable Burial

11.147. The assessment of sediment plume creation and dispersal of sediment from array cable burial follows the rationale above for foundation. Elevated concentrations of sediment will be short-term (days) and, assuming that the installation activities occur continuously across the seabed within Project Alpha, will only experience limited release of sediments.

11.148. The worst case scenario for array cable installation equates to some 355km of cable, installed using jetting, to a depth of between 0.5m and 2.1m along a corridor of 3.0m width.

11.149. The total volume of seabed sediments that might be mobilised will be released in a phased approach dependent upon the rate of excavation and the duration of array cable installation activity within the 3 year construction programme. Furthermore, the jetting approach will fluidise or liquefy the seabed sediments and therefore they will remain near to the bed. Consequently, there will not be the bulk loading of sediment into the marine environment in significant quantities. Indeed, much of the sediment released by jetting within Project Alpha is likely to settle back in the immediate vicinity of its release due to its relatively coarse grain size. Any sediment that does remain in suspension will become dispersed by the prevailing tidal currents in low concentrations. As presented in Chapter 7: Physical Environment this effect on suspended sediment levels is considered to be of low magnitude.

11.150. As both the effects of GBS seabed preparation and array cable installation are considered to be of low magnitude in terms of the physical environment it can also be considered that the effect on the benthos will be of low magnitude. Furthermore, the Project Alpha Site currently experiences scallop dredging activities, an activity which is known to elevate SSC. All habitat types identified across the Project Alpha Site, for which assessments are available, are considered to have low sensitivity or are not sensitive to smothering (Table 11.8), therefore, the sensitivity of the receptor is considered to be low. Using the matrix provided in Table 11.5 the indirect impacts on benthos due to increased suspended sediments are likely to be negligible and **not significant**.

Mitigation

Mitigation

The site selection process will aim to situate GBS foundations (if used) in areas that will require the least amount of ground preparation therefore reducing the potential release of sediments.

If jacket foundations are used, no ground preparation is required.

Residual Impact

11.151. If GBS are not used or located to reduce the need for ground preparation, the volumes of released sediment will be reduced from that considered in the above assessment. The impact will remain of negligible and **not significant**.

Indirect impacts on benthos through re-mobilisation of contaminated sediments

11.152. Sediment disturbance during the construction of Project Alpha could lead to remobilisation of contaminants held within the sediments when sediments are resuspended during cable installation or ground preparation. As presented in Chapter 8: Water and Sediment Quality (Tables 8.5 and 8.10) sediment analysis has indicated that contaminant conditions for the Project Alpha area are below levels at which adverse effects on the benthos are likely to be seen (see Section 8.4). Elevated levels of arsenic were detected at all but one station, however these levels did not exceed the Cefas Action Level 1 standards (see Section 8.4)

which are expected to cause adverse impacts on the benthos. The widespread presence of these low levels of arsenic is thought to indicate a natural origin (as opposed to a pollution derived origin).

11.153. Suspended sediment plumes and resultant deposition will be temporary, the suspended sediment concentration increases involved are small and the footprint of impact will largely be restricted to the immediate vicinity of the works (see above). Therefore the magnitude of the impact is considered to be low within the affected area.

11.154. The sparse polychaete/ bivalve habitat (equivalent biotope SCS.ICS.MoeVen) is likely to be the most vulnerable to increased levels contamination and has been judged to have a moderate sensitivity and high intolerance to heavy metals (Durkin, 2008). Therefore this habitat is considered to have medium sensitivity. Following the matrix in Table 11.5, it is anticipated that the impact of re-mobilised contaminants on the subtidal benthos will be minor adverse and not significant. It should be noted however, that as mentioned above (paragraph 11.145) any increases in suspended sediments and therefore associated contaminants have to be seen in the context of regular disturbance of the seabed from scallop dredging activities which will likewise resuspend contaminants into the water column.

Mitigation

Mitigation

The site selection process will aim to situate GBS foundations (if used) in areas that will require the least amount of ground preparation therefore reducing the potential release of sediments.

If jacket foundations are used, no ground preparation is required.

Residual Impact

11.155. If GBS are not used or are located to reduce the need for ground preparation, the volumes of released sediment will be reduced. From a precautionary standpoint, it is considered that in the vicinity of disturbance the impact would remain minor adverse and **not significant.**

Project Bravo

Direct impact on benthos due to physical disturbance

11.156. As discussed for Project Alpha (see paragraphs 11.120 to 11.131 above) the installation of the wind farm components and infrastructure (including array cables, foundations, WTG, OSPs and meteorological masts) via jack-up barges, ROVs and other vessels will result in the temporary disturbance to the benthos. This potential impact was identified by SNH through the scoping process (Table 11.1).

11.157. The maximum potential area of disturbance has been calculated as 374.84ha (Table 11.12b with a breakdown of how this was calculated is presented in Appendix G4 which can be found in ES Volume III) This equates to 1.94% of the 193,65ha Project Bravo consent envelope area. The worst case for physical disturbance will constitute displacement of sediment and damage or loss of communities within a 374.84ha area.

11.158. In terms of the impacts on the different habitat types mapped by Envision (Figure 11.5), the worst case scenario would be that all of the Project Bravo infrastructure would be built within the most sensitive habitat type. Table 11.8 summarises the sensitivity of the habitats across the Project Bravo Site and Table 11.14 below provides calculations of the area of disturbance and the relative percentages of the ISA and Project Bravo Site. The most sensitive habitat is *Sabellaria*

(equivalent biotope SBR.PoR.SspiMx), which has been defined as having a moderate biological sensitivity (as defined in Table 11.8), or in the context of this ES is considered to be of medium sensitivity. The area of disturbance of Project Bravo (375.95ha) is 3.3% of the entire area of ISA that was identified as being *Sabellaria* habitat (Table 11.14).

11.159. Array cable installation and the depressions created by jack-up barge legs will be another source of temporary impact upon the benthos (see above for discussion for Project Alpha). These impacts are expected to be temporary and of low magnitude.

11.160. *Sabellaria spinulosa* individuals were identified at 14 grab sample locations, three video sample locations and two epifaunal sample locations within the Project Bravo Site. A habitat which occurs across the central southern area of the Project Bravo Site (Figure 11.5) was characterised by Envision as '*Sabellaria*' (Appendix G2 which can be found in ES Volume III). However, no dense aggregations or reefs (as defined by Gubbay, 2007) have been recorded within the site boundary.

11.161. As with Project Alpha, the only habitat identified within the Project Bravo Site listed under the EC Habitats Directive and the UK Biodiversity Action Plan (Hill, 2008) is dense *Amphiura/ Phoronis* (equivalent biotope SS.SMu.CSaMu.AfilMysAnit). Very small patches of this habitat (totalling 26ha) are found in the extreme south west corner of the Project Bravo Site (Figure 11.5). This habitat is considered "not sensitive" to smothering or increase in suspended sediments (the most relevant causes of physical disturbance). If Project Bravo infrastructure were to be located in this area and disturbed all available habitat within the Project Bravo Site this would amount to only 9.3% of *Amphiura / Phoronis* habitat within the ISA. The magnitude of this impact is consequently considered to be low.

11.162. As discussed previously (see above) following construction, the majority of subtidal species and habitats identified at the site (Table 11.8) exhibit good potential to recover, particularly to localised and short term disturbance of this nature. It is anticipated that the benthic community in the area impacted will recover to pre-impact levels and species richness following construction.

Table 11.14 Areas of disturbance and habitat loss at the Project Bravo Site

Habitat (Envision)	Bravo Site		ISA (extent of known benthic habitats)	
	Area within Bravo (ha)	% of Project Bravo Site area	Project footprint as a % of habitat within ISA.*	Area of disturbance as a % of habitat within ISA.*
Dense *Amphiura/ Phoronis*	26	0.1	2.2	9.3
Dense *Chone*	8826	45.6	0.7	3.1
Epifauna/ polychaete	1762	9.1	2.5	10.9
Polychaete/ bivalve	707	3.7	1.8	10.0
Rich polychaetes	4672	24.2	1.0	4.2
Sabellaria	2028	10.5	0.8	3.3
Sparse *Chone*	718	3.7	1.6	6.7
Sparse polychaete/ bivalve	600	3.1	0.9	3.8

*In the worst case scenario the entire Project Alpha would be built in one single habitat, therefore this calculation is of the area of each habitat that would be lost if this theoretical scenario occurred.

11.163. Given that only a small proportion (1.94%) of seabed within the Project Bravo Site will be affected and that even if all of the infrastructure were placed so that it disturbs the most sensitive habitats or those of the highest conservation concern only disturb a maximum of 9.3% of the area of that habitat known to occur within the ISA, the magnitude of the impact will be medium to low.

11.164. The species and habitats will recover quickly following construction, are widespread within the area and the single habitat of conservation concern has been identified unlikely to be significantly impacted by construction of Project Bravo; therefore they are of low sensitivity.

11.165. Following the matrix in Table 11.5 it is considered that this impact of direct physical disturbance of subtidal benthic species and habitats will be of minor adverse to negligible and **not significant**. As site specific data has been collected using a range of techniques the confidence in this assessment is considered high.

11.166. If *Sabellaria* were present in reef form, this would be of higher sensitivity than the other habitats found within the Project Bravo Site and adverse impacts would potentially have greater significance. However, to date no *Sabellaria* reef has been recorded at the site.

Mitigation

Mitigation

Avoid siting of infrastructure in areas of sensitive habitat (Dense *Amphiura/ Phoronis* and *Sabellaria* which are mainly located in the south west of the Project Bravo Site (Figure 11.5) where ever practicable.

As part of the pre-construction survey (which will be agreed with Marine Scotland) data will be analysed to ascertain the presences of any rare or important habitats, such as *Sabellaria* or *Modiolus* reefs; and

Micrositing of infrastructure, if pre-construction surveys were to identify any areas that are considered to constitute *Sabellaria* spinulosa reefs and subsequent consultation with Marine Scotland to ensure that planned installation would not have a significant adverse impact on any reef features.

Residual Impact

11.167. With these mitigation measures in place the magnitude of the impact will be reduced but the significance will remain at negligible and **not significant.**

Direct impact on benthos due to the loss of habitat

11.168. As discussed for Project Alpha (see paragraphs 11.132 to 11.141 above) the positioning of structures on the seabed will result in long term loss of seabed and associated habitats and fauna within the footprint of the structures for the life of the scheme (circa 25 years).

11.169. The worst case build scenario has been detailed in Table 11.12b and identifies that the structures which will result in seabed take will be: WTG foundations, ancillary structures, cable protection, meteorological masts and scour protection. The maximum loss of seabed is anticipated to be 112ha (see Table 2 in Appendix G4 which can be found in ES Volume III, for a breakdown of the different components in this calculation). The total area affected will constitute 0.58% of the total Project Bravo consent area (194km^2). The majority of seabed lost will be as a result of the WTG foundations and associated scour protection.

11.170. Any reduction from the worst case in terms of materials required on the seabed will reduce the area of habitat loss. The biotopes present across the Project Bravo Site are discussed in

Section 11.4. Table 11.8 summarises these biotopes and assesses their value and sensitivity and Table 11.14 provides calculations of the potential area of habitat loss relative to the ISA and Bravo Project Site.

11.171. As discussed in paragraphs 11.156 to 11.167 above, and in Table 11.11b, the worst case scenario would be that the entire Project Bravo would be located within, or cover, the most sensitive habitats which have been identified as the *Saballaria* and Dense *Amphiura/ Phoronis* habitats (Table 11.8). If this unlikely scenario is realised then a theoretical maximum of 111.9ha of the *Sabellaria* habitat could be lost and the entire 26 hectares (ha) of Dense *Amphiura/ Phoronis* habitat present within the Bravo site could be lost (Table 11.13). However, this represents just 1% of the *Sabellaria* habitat and 2.8% of the *Amphiura/ Phoronis* habitat known to occur within the ISA.

11.172. Although the *Sabellaria spinulosa* individuals were identified at numerous sites through the benthic survey (see Figure 11.12 and paragraphs 11.156 to 11.167 above) and a habitat was characterised by Envision as "*Sabellaria*" (Appendix G2 which can be found in ES Volume III) there were no dense aggregations or reefs (as defined by Gubbay, 2007) recorded within the site boundary.

11.173. Given that the area of potential habitat loss represented by building Project Bravo will be small in relation to the known habitat resource within the ISA, the magnitude of the impact is considered to be low.

11.174. There are less diverse habitats within the Project Bravo Site than in the Project Alpha Site and the sensitive habitats are confined to small areas in the west of the site and therefore, although this impact will be permanent (for the life of the project) the sensitivity of the habitats are considered less than those in Project Alpha. The sensitivity of the receptor in the equivalent impact within Project Alpha was assessed to be medium whereas in Project Bravo they are considered to be low. Therefore the significance of the impact is considered to be negligible and **not significant.**

11.175. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resulting impacts will not exceed those predicted.

Mitigation

Mitigation

Avoid siting of infrastructure in areas of sensitive habitats (Dense *Amphiura/ Phoronis* and *Sabellaria*), which are located within the west of the site (Figure 11.5) wherever practicable.

As part of the pre-construction survey (which will be agreed with Marine Scotland) data will be analysed to ascertain the presences of any rare or important habitats, such as *Sabellaria* or *Modiolus* biogenic reef.

If pre-construction surveys were to identify any areas that are considered to constitute biogenic reef, these could be avoided or infrastructure micro-sited in consultation with Marine Scotland to ensure that planned installation would not have a significant adverse effect on any reef features.

Residual Impact

11.176. If the above mitigation is implemented then the magnitude of the impact will be reduced but the significance of the impact is likely to remain at negligible and **not significant.**

Indirect impacts on benthos due to increased suspended sediments

11.177. As discussed in paragraphs 11.142 to 11.151 above for Project Alpha, increased suspended sediment load has the potential to impact on marine benthos through blockage to the sensitive filter feeding apparatus of certain species and / or smothering of sessile species upon deposition of the sediment.

11.178. As the design of Project Alpha and Project Bravo are similar and they are both to be constructed on very similar substrates the assessment of this impact is largely the same. The main activities which could lead to increased SSC have been identified as seabed preparation for the installation of GBS foundations and the installation of array cables. The modelling of the resultant sediment plumes from both these activities is applicable to both sites and is presented in Chapter 7: Physical Environment and summarised above. A negligible magnitude of effect was predicted for both seabed preparation and installation of array cables and therefore the resultant magnitude of the impacts to the benthos within the Project Bravo Site are also considered to be negligible and **not significant**.

11.179. All habitats identified as present within the Project Bravo Site, for which assessments are available, are either not sensitive or have low sensitivity to smothering (Table 11.8) and as a consequence the sensitivity of the receptor is considered to be low. Furthermore, in common with the Project Alpha Site, the Project Bravo Site also currently experiences scallop dredging activities which will elevate the levels SSC within the area. Therefore it is likely that the impact on benthos due to increased suspended sediments will be negligible and **not significant**.

11.180. Given that site specific data have been collected and the effects on the habitats are well known, there is a high degree of confidence that the resulting impacts will not exceed those predicted.

Mitigation

Mitigation

If GBS foundations are used, they should be located with regard minimisation of ground preparation to reduce the potential release of sediments.

If jacket substructure/ foundations are used, no ground preparation is required.

Residual Impact

11.181. If GBS are not used or located to reduce the need for ground preparation, the volumes of released sediment will be reduced. The impact will remain negligible and **not significant** significance.

Indirect impacts on benthos through re-mobilisation of contaminated sediments

11.182. As discussed in paragraphs 11.152 to 11.155 above sediment disturbance and the subsequent re-suspension of contaminants within them may impact benthic habitats and species. As presented in Chapter 8: Water and Sediment Quality Tables 8.5 and 8.10, sediment analysis has indicated that contaminant levels within the sediments in the Project Bravo area are below levels at which adverse effects on the benthos are seen, with only elevated levels of arsenic detected in the sampling program. Although elevated levels of arsenic were detected at all stations within the Project Bravo Site, these levels did not exceed the Cefas Action Level 1 standards above which adverse impacts on the benthos could occur.

11.183. The levels of re-suspension of sediment during construction will be negligible as discussed above and the levels of contaminants within them will be small, therefore the overall magnitude of the impact will be low.

11.184. The sparse polychaete/ bivalve habitat (equivalent biotope SCS.ICS.MoeVen) is likely to be the most vulnerable to increased levels contamination and has been judged to have a moderate sensitivity and high intolerance to heavy metals (Durkin, 2008) and therefore for the purposes of this assessment considered to be of medium sensitivity. This habitat is however only present in a small area within the south east of the Project Bravo Site and therefore the likelihood of impact upon this habitat is very low. It is therefore considered that the impact of re-mobilised contaminants on the benthos will be minor adverse and **not significant**. It should be noted; however, that as mentioned above any increases in suspended sediments and therefore associated contaminants have to be seen in the context of regular disturbance of the seabed from scallop dredging activities which will likewise suspend potential contaminants in the water column.

Mitigation

Mitigation

If GBS foundations are used, they should be located with regard minimisation of ground preparation to reduce the potential release of sediments.

If jacket substructure/ foundations are used, no ground preparation is required.

Residual Impact

11.185. If GBS are not used or located to reduce the need for ground preparation, the volumes of released sediment will be reduced. From a precautionary standpoint, it is considered that in the vicinity of disturbance the impact would remain minor adverse.

Transmission Asset Project

Direct physical disturbance of subtidal benthic species and habitats

11.186. The effects of direct physical disturbance of the OSP substructure/ foundations and their construction have already been determined as an integral part of the assessments for Projects Alpha and Bravo. The worst case for impacts caused by the Transmission Asset Project is Scenario 1 (See Section 5.4 in Chapter 5: Project Description). This scenario will result in an area of disturbance of up to 1.27ha which is considerably less area than Project Alpha and Project Bravo. During the assessments of physical disturbance within Alpha and Bravo construction impacts were considered to be negligible and **not significant** significance and therefore the significance of the Transmission Asset project should also be negligible and **not significant**. The installation of the export cables will result in temporary disturbance to the benthos, as identified by SNH through the scoping process (Table 11.1). As the vehicle which is installing the cable moves over the seabed it could disturb a corridor estimated to be up to 15m wide (as presented in Chapter 5: Project Description within this ES).

11.187. Calculations for the greatest possible area of direct disturbance are given in Table 11.11c. The worst case scenario for cable installation is that six cables will be installed resulting in a maximum area of disturbance of 796.27ha of habitat. Disturbance will take the form of displacement of sediment, depressions in the seabed and damage to or loss of the communities directly within the footprint of the cable installation vehicle (Table 11.11c).

11.188. In terms of the impacts on the different habitat types mapped by Envision (Figure 11.7), the worst case scenario would be that six cables are installed and the maximum possible

distance is within the most sensitive habitats. Eight of the habitats identified as present within the ECR have been assigned a sensitivity value of moderate (Table 11.11). The maximum area of disturbance of the export cables is displayed in Table 11.15. Due to the linear nature of the cable and the fact that the cables may weave between obstacles on the seabed it is difficult to quantify the worst case area of disturbance that may occur to each habitat. However, the method used measures the maximum possible distance of each distinct habitat area through which a cable could pass and then multiplies this by 90 (15m width of disturbance for each of the 6 export cables).

11.189. Table 11.15 shows the maximum possible distances of cable installation through each habitat and the potential area of disturbance calculated, with the area of disturbance also presented as a percentage of the overall amount of each habitat known to occur within the ECR survey area.

Table 11.15 Maximum areas of disturbance to sensitive (as identified in Table 11.11) subtidal habitats within the ECR Corridor.

Habitat	Maximum length of cable likely within habitat (km)	Area in Hectares (ha)	Disturbance as a percentage of the known area of habitat within the ISA (%)
Dense *Amphiura/ Phoronis*	30.9	278.1	6.9
Cobble/ faunal turf	7.9	71.1	15.7
Fabulina	16.2	145.8	22.5
Sabellaria	10.8	97.2	0.84
Sparse *Amphiura*	31	99.2	0.34
Sparse polychaete/ bivalve	6.9	62.1	<0.01
Rock Faunal Turf	0.19	1.71	0.81
Thyasira	13.4	120.6	80.3

11.190. The percentage area of sensitive habitats that the ECR could potentially impact upon range from <0.01% to 80.29% (Table 11.15). These impacts will however be temporary as once the cable installing device (cable plough, jet trencher or cutter) has passed over an area the habitat is likely to rapidly recover and therefore the magnitude of the impact is considered to be low.

11.191. As outlined in Table 11.11 several habitats known to occur within the ECR corridor are considered to be of medium sensitivity. Therefore, it is considered that the impact of direct disturbance on benthic habitats will be minor adverse and **not significant**.

11.192. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resulting impacts construction will not exceed those predicted.

Mitigation

Mitigation

Where possible the cable route should aim to avoid the more sensitive habitats (Table 11.11) and where this is not possible the route should take the shortest distance possible through the sensitive areas.

Residual Impact

11.193. If the advised mitigation measures suggested above are implemented the magnitude of the impact will be reduced to low and therefore the residual impact is likely to be negligible and **not significant**.

Direct impact on benthos due to the loss of habitat

11.194. The effects of habitat loss caused by the OSP substructure/ foundations and their impact during construction phase have already been determined as an integral part of the assessments for Projects Alpha and Bravo.

11.195. The positioning of OSPs and associated scour protection on the seabed as part of the construction of the Transmission Asset Project will result in long term loss of seabed and associated habitats and fauna within the footprint of the structures for the life of the scheme (circa 25 years). This impact was assessed as being of minor adverse significance in project Alpha and negligible significance within Project Bravo. However the percentage of this impact that was caused by the OSPs was approximately 0.14% and therefore the construction of the OSPs in isolation would have a negligible and **not significant** impact.

11.196. Over the majority of the ECR, the cables will be buried and therefore there will be no loss of habitat. Where cable protection which may take the form of rock protection, grout bag protection or concrete mattress (as presented in Section 5 of Chapter 5: Project Description) is required, there will be a loss of habitat. It has been estimated that the maximum length of cable that will need protection (rather than being buried) will be 10% of the overall length of cable. Up to six export cables with a combined length of 530km may be incorporated into the Transmission Asset Project and therefore a maximum of 53km will be protected.

11.197. The maximum width of the cable protection will be 7m and therefore the maximum area of habitat loss would be 37.1ha. The area of each of the sensitive habitats that could potentially suffer habitat loss is presented in Table 11.16.

Table 11.16 Maximum areas of habitat loss of the more sensitive subtidal habitats (as identified in Table 11.11) within the ECR corridor.

Habitat	Maximum length of cable likely within habitat (km)	Maximum area of habitat loss (ha)	Habitat loss as a percentage of the known area of habitat within the ISA (%)
Dense Amphiura/ Phoronis	30.9	13.0	0.32
Cobble/ faunal turf	7.9	3.3	0.73
Fabulina	16.2	6.8	1.05
Sabellaria	10.8	4.5	0.04
Sparse Amphiura	31	13.0	1.59
Sparse polychaete/ bivalve	6.9	2.9	0.03
Rocky Faunal Turf	0.19	0.1	0.04
Thyasira	13.4	5.6	3.75

11.198. The maximum percentage of habitat loss within the ISA of any one habitat that could occur from the installation of export cables is 3.75% (Thyasira habitat as shown in Table 11.16). This impact will be long term (for the life of the project), but will be small scale and therefore is considered to be of a low magnitude.

11.199. Thyasira habitat was determined as having 'moderate' sensitivity as defined by MarLIN (see Table 11.11) which is interpreted as medium sensitivity for the purposes of this ES, therefore the impact of habitat loss within the ECR component of the Transmission Asset Project is predicted to be of minor adverse and **not significant**.

11.200. Given that site specific data has been collected and the effects on the habitats are well known, there is a high degree of confidence that the resulting impacts will not exceed those predicted.

Mitigation

Mitigation

Localised habitat loss during the cable installation is an unavoidable consequence of the Seagreen Project. Best practice guidance will be followed to ensure that potential habitat loss is minimised throughout the proposed works. The amount of rock, grout bags or mattresses used to protect the cable will be kept to the minimum amount (which may be less than the worst case estimate of 10% of the ECR) necessary to ensure protection

Residual Impact

11.201. If the advised mitigation measures suggested above are implemented the magnitude of the impact will be reduced to negligible and therefore the significance of the impact will become negligible and **not significant**.

Indirect impacts on benthos due to increased suspended sediments

11.202. Increased suspended sediment load has the potential to impact benthos through blockage to the sensitive filter feeding apparatus of certain species that occur within the Transmission Asset area. The only pathway that exists for the infrastructure within Project Alpha and Project Bravo as part of the Transmission Asset Project to increase the suspended sediments is through the installation of OSPs.

11.203. The impact of increasing sediment through the construction of the OSPs is assessed within Project Alpha and Project Bravo both of which were determined as being of negligible significance. Therefore it can be assumed that the impact of constructing the OPS within the Transmission asset project will be negligible and **not significant**.

11.204. Elevated levels of SSC within the ECR have the potential to impact upon benthic species by impairing filter feeding apparatus or by smothering of organisms. As presented in Chapter 7: Physical Environment the worst case scenario for export cable installation assumes the use of jetting and a target burial depth of up to 3m for six cables.

11.205. The dispersal of sediment will arise during installation of the ECR, but elevated SSC levels in the water column will be short-term (a few days), assuming that the installation activities occur over a continuous 10-day period. The sediment mobilised by jetting will be deposited on the seabed close to the cables with the level of deposition being dependent upon the sediment grain size and the strength and orientation of tidal currents. The assessment of effects upon suspended sediment concentrations in Chapter 7: Physical Environment predicts that the impact will be of low magnitude.

11.206. Given the levels of contaminants recorded within the sediments (as discussed in Chapter 8: Water and Sediment Quality and above in this section) the potential magnitude on impact from re-suspended contaminants will also be low.

11.207. Of the potential habitats that could be affected by increased levels of suspended sediment, for which assessments are available, all are either not sensitive or have low sensitivity to smothering (see Table 11.11) and so the sensitivity of the receptor can be considered to be low. In addition the ECR area within the Transmission Asset Project is subject to scallop dredging (see Chapter 14: Commercial Fisheries) an activity which is known to elevate SSC levels. Therefore, it is likely that the impact of indirect impacts on benthos through increased suspended sediments and re-mobilisation of contaminated sediments will be negligible and **not significant**.

11.208. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resulting impacts will not exceed those predicted.

Mitigation

Mitigation

Short-term and localised changes to sediments and sedimentary structures during the construction phase of the proposed works are an unavoidable consequence of the Seagreen Project. Best practice guidance will be followed to ensure that potential damage to environmental features is minimised throughout the proposed works.

Residual Impact

11.209. The adherence to best practice guidance may reduce the magnitude of the impact but the significance will remain at negligible and **not significant**.

Direct impact on intertidal ecology due to physical disturbance

11.210. The potential impact of the proposed development upon intertidal ecology was raised by SEPA in the scoping opinion. Up to six export cables will be installed across the intertidal area at the landfall location south of Carnoustie (Figure 11.1).

11.211. The cables will be installed using a method called Horizontal Directional Drilling (HDD). HDD is a steerable, trenchless method of installing underground cable ducts by launching them from a drilling pit, with minimal impact on the surrounding area. The drill rig area will be located behind (above) the coastal defences and the ducts will be installed and a borehole will be drilled from the transition pit under the sea defences and out to the mean low water mark. Some trenching at the seaward entrance to the ducts within the lower intertidal or shallow subtidal will be required to install the cables into the ducts to be pulled through to the transition pit. The trenching may involve vehicle access and may require the construction of an access track for light vehicles that would cross the Barry Burn above MHWS to the north of where the export cables will come ashore. Small lightweight vehicles may then access the shore using this track. As the vehicles are lightweight they will cause only minimal and temporary disturbance to the intertidal habitats which are likely to be of a low magnitude of impact.

11.212. The intertidal habitats at the landfall site have low species richness and are typical of a beach exposed to high currents and wave action, with mobile sediments and devoid of benthic fauna (see Appendix G3 in ES Volume III). The intertidal surveys at Carnoustie found that as with most shore lines the habitat zones run parallel to the coastline and as the cables will be installed perpendicular to the coastline disturbance will be limited to small areas of each habitat. In addition the disturbance of the intertidal area will be temporary in nature and it is likely that the habitats and species will rapidly recover rapidly to pre-cable installation levels and therefore the magnitude of the impact is considered to be low.

11.213. Given that the intertidal habitats at Carnoustie have low species richness and were not found to be unique or rare, the sensitivity of the intertidal habitats is considered to be low. Therefore, the impact on intertidal ecology due to direct physical disturbance is considered to be negligible and **not significant**.

11.214. The fact that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resulting impacts will not exceed those predicted.

Mitigation

Mitigation

Best practice measures will be employed by Seagreen, based on lessons learnt from equivalent cable installations across sandy shores, to ensure that the significance of potential impacts remain as negligible, these include:

- Limiting the number of vehicle operations across the intertidal area.
- Ensuring that any vehicle operations keep to designated areas of minimal practicable size
- Lay down of tracking if appropriate in areas of softer sand.

Residual Impact

11.215. If best practice is followed then the impacts to intertidal ecology are likely to remain negligible and **not significant.**

Effects on Nature Conservation designations

11.216. The ECR corridor overlaps with the Firth of Tay and Eden Estuary SAC (Figure 11.16) by approximately 87ha which is 0.56% of the 15,412ha designation. Due to the location of the onshore cable route it is unlikely that the offshore cable route will be placed within the SAC (See Figure 11.16), however it may encroach over a small distance, therefore the magnitude of this impact is considered to be negligible.

11.217. The Firth of Tay and Eden Estuary SAC is designated as an SAC primarily for "Estuaries", but also has as a qualifying feature, but not a primary reason for selection "Intertidal mudflats and sandflats" (JNCC, undated). The Intertidal survey (see Appendix G3 in ES Volume III) and the geophysical surveys (Chapter 7: Physical Environment and Figure 11.7) indicate the area through which the cable will installed does contain sandy substrate and may therefore contain sandflats. As sandflats are not the primary reason for the designation of the SAC and the disturbance will be short term the sensitivity of this receptor is considered to be medium. Therefore impacts of the transmission asset project on the Firth of Tay and Eden Estuaries SAC is considered to be negligible and **not significant**.

Mitigation

Mitigation

Short-term and localised changes to sediments and sedimentary structures during the construction phase of the proposed works are an unavoidable consequence of the Seagreen Project. Best practice guidance will be followed to ensure that potential damage to environmental features is minimised throughout the proposed works.

The adherence to best practice guidance may reduce the magnitude of the impact but the significance will remain at negligible.

IMPACT ASSESSMENT – OPERATION

Project Alpha

Direct impact on benthos due to physical disturbance caused by maintenance activities

11.218. During operation of Project Alpha it may be necessary to access the buried array cables using an ROV or access the WTG, ancillary structures or meteorological masts using a jack up barge for planned and unplanned maintenance or repair. This may cause localised disturbance to the benthic assemblages directly surrounding the cables or other structures. (see Table 11.12a). It is not possible to estimate how many vessel movements may be required, in particular for any required unplanned operations over the life of the Project Alpha. However, any disturbance will be of limited duration and the best practice guidelines will be followed to further limit any disturbance.

11.219. During maintenance activities only a very small area of the seabed will be impacted at any one time, any disturbance will be short-term and sporadic and therefore the magnitude of this impact will be negligible. Given the recoverability of the species of the benthic communities (Table 11.8), their sensitivity to these impacts is considered to be low to moderate. Therefore, it is considered that the potential impact on benthic communities due to maintenance activities will be negligible and **not significant**.

11.220. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

No mitigation measures are available for this impact; works will be limited only to those necessary for scheduled or emergency maintenance.

Residual Impact

11.221. As no mitigation measures are available the impact on benthos due to physical disturbance will remain negligible and **not significant**.

Direct impacts on subtidal benthos due to creation of new habitat

11.222. The presence of up to 75 WTG and up to 3 OSP substructure/ foundations, scour protection (where utilised) and cable protection material will change the nature of the subtidal habitat. The impacts of the direct loss of the existing habitat are assessed as part of the impacts during construction (see paragraphs 11.132 to 11.141). The change will comprise the replacement of natural sedimentary seabed with steel piles, concrete foundations and scour protection material.

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

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

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

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

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

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

11.229. Whilst increases in biodiversity could serve as a benefit to the receiving environment, in the context of this ES, any change from baseline conditions as a result of anthropogenic activity will not be considered to be a beneficial impact as it will reduce the "naturalness" of the area. However, given the uniform nature of the communities across the ISA it is considered that they have a low sensitivity to localised changes in community composition.

11.230. The impact on the subtidal environment due to the alteration of habitat will be of **negligible** significance.

11.231. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation
No mitigation measures are available for this impact.

Residual Impact

11.232. As no mitigation measures are advised the impact on benthos due to habitat creation will remain negligible and **not significant**.

Indirect impacts on benthos due to changes in current regime and coastal processes

11.233. Changes in current regime and coastal processes have the potential to alter the parameters within which benthic habitats exist, therefore potentially altering the communities that can survive in the area.

11.234. Table 7.24 presented in Chapter 7: Physical Environment identifies worst case scenarios with regard to operational effects on the hydrodynamic and consequently, sedimentary regime. The assessment of effects on hydrodynamic regime change during operation of Project Alpha identified two main effects of the project: wave height and period and tidal current velocity and vectors. Both were assessed as being of negligible significance and therefore it is likely that the resultant impact to benthic ecology will be of negligible magnitude.

11.235. Few studies have specifically investigated the sensitivity of the habitats present within the Project Alpha Site (as identified by Envision Mapping Ltd (2011), see Figure 11.5), however, the habitats Dense *Amphiura*/ *Phoronis* (equivalent biotope SS.SMu.CSaMu.AfilMysAnit) and Sparse polychaete/ bivalve (equivalent biotope SCS.ICS.MoeVen) have been identified as being of moderate and low sensitivity to changes in flow rates (Hill, 2008 and Dunkin, 2008 respectively). Taking a precautionary approach the sensitivity of the habitats is considered to be medium. Therefore, the impact of on benthos due to changes in current regime and coastal processes will be negligible and **not significant**.

11.236. Given that site specific data has been collected and the effects on the habitats are well known there is a medium to high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

Variations in OWF layouts can result in the reduction of effects upon the hydrodynamic regime. However, it is not anticipated that the proposed layouts shall result in significant adverse effects upon the hydrodynamic regime since a worst case minimal spacing between turbines of 5 rotor diameters has been assessed. No mitigation is required.

Residual Impact

11.237. As no mitigation measures are advised the impact on benthos due changes in current regime and coastal processes will remain negligible and **not significant**.

Indirect impacts on benthos due to alteration to existing human activity

11.238. Commercial scallop dredging is the principle fishery that occurs across the Project Alpha Site with a small, but potentially expanding, squid fishery (see Chapter 14: Commercial Fisheries). This type of activity can alter habitats leading to less diverse habitats dominated by short lived, opportunistic species (Engel & Kvitek 1998; Jennings & Kaiser 1998; Thrush & Dayton 2002 and Kaiser *et al.*, 1996).

11.239. Whilst fishing activity will not be excluded within the Project Alpha Site, safety zones of 50m surrounding each offshore structure and a 500m safety zone surrounding maintenance activities will be applied for (see Chapter 5: Project Description). Therefore the levels of dredging activity may reduce within Project Alpha which may decrease subsequent impact on the marine benthos.

11.240. It is difficult to quantify the level to which dredging within the Project Alpha Site will be reduced and it is the Applicants aim to minimise impacts upon fisheries operating within the site, therefore the magnitude of the this impact is considered to be low.

11.241. A reduction in fishing activity could aid in the recovery of areas that have been disturbed and could increase the development of habitats of higher diversity and complexity. However, due to the uncertainties surrounding the change in fishing activity, the potential for a beneficial impact upon benthic ecology cannot be confirmed at this stage. It is anticipated that the subsequent impact on the benthos will be negligible and **not significant.**

11.242. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

No mitigation measures advised

Residual Impact

11.243. As no mitigation measures are advised it is likely that the impact on benthos due to alteration to existing human activity will remain negligible and **not significant**.

Project Bravo

Direct impact on benthos due to physical disturbance caused by maintenance activities

11.244. As the habitats across the Project Bravo Site are broadly similar to those found across the Project Alpha Site and the maintenance activities across the two sites are expected to be broadly similar, the magnitude is predicted to be negligible, the sensitivity medium and therefore the significance of impact is negligible and **not significant.**

11.245. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

No mitigation measures advised

Residual Impact

11.246. As no mitigation measures are advised it is likely that the impact on benthos due to physical disturbance will remain at negligible and **not significant**.

Direct impacts on subtidal benthos due to creation of new habitat.

11.247. As Project Bravo is broadly comparable to Project Alpha in terms of size and infrastructure it is predicted that the impact of habitat creation will be of the same **low** magnitude for both projects. Given the uniform nature of the habitats across Project Bravo it is considered that they have a low sensitivity to localised changes in community composition. Therefore the impact is likely to be negligible and **not significant**.

11.248. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

No mitigation measures advised

Residual Impact

11.249. As no mitigation measures are advised the impact on the benthos due to habitat creation will remain negligible and **not significant**.

Indirect impacts on benthos due to changes in current regime and coastal processes

11.250. Effects on current regime and coastal processes were assessed as being of negligible significance during operation (see Chapter 7: Physical Environment) and therefore it is likely that the resultant impact to benthic ecology will be of negligible magnitude.

11.251. Given that the habitats identified as present within the Project Bravo Site are similar to those seen in the Project Alpha Site, they are assumed to have the same sensitivity, which taking the precautionary approach used for Project Alpha gives a habitat sensitivity of medium. Therefore the impact of on benthos due to changes in current regime and coastal processes will be negligible and **not significant**.

11.252. Variations in OWF layouts can result in the reduction of effects upon the hydrodynamic regime. However, it is not anticipated that the proposed layouts will result in significant adverse effects upon the hydrodynamic regime since a worst case minimal spacing between turbines of 5 rotor diameters has been assessed.

11.253. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resulting impacts will not exceed those predicted.

Mitigation

Mitigation
No mitigation measures advised

Residual Impact

11.254. As no mitigation measures are advised the impact on the benthos due changes in current regime and coastal processes will remain negligible and **not significant**.

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

11.255. As discussed for Project Alpha scallop dredging is the principle fishing activity that occurs within the Project Bravo Site (see Chapter 14: Commercial Fisheries). Equivalent safety zones will be applied for as part of Project Alpha and Project Bravo and therefore, the likely impacts to commercial fishing and subsequent effects on benthic communities are predicted to be of the same as seen in Project Alpha. The magnitude of impact and sensitivity of the receptor are both considered to be low and therefore the significance of this impact is likely to be negligible and **not significant**.

11.256. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resulting impacts will not exceed those predicted.

Mitigation

Mitigation
No mitigation measures advised.

Residual Impact

11.257. As no mitigation measures are advised the impact on the benthos due to alteration to existing human activity will remain negligible and **not significant**.

Transmission Asset Project

Increased suspended sediments and mobilisation of contaminants leading to smothering of benthic ecology

11.258. The effects of increased suspended sediment caused by the OSP substructure/ foundations during operation have already been determined as an integral part of the assessments for Projects Alpha and Bravo (see paragraphs 11.142 to 11.155 and paragraphs 11.177 to 11.184 above). In both cases they were predicted to be negligible and therefore as the components of the Transmission Asset Project are far smaller than those assessed as part of Project Alpha and Project Bravo these impacts will also be negligible and **not significant**.

11.259. Once the export cable is buried and in operation it is predicted to have **no impact** as it will not lead to increased suspended sediments.

Mitigation

Mitigation

No mitigation measures are available for this impact.

Residual Impact

11.260. It is likely that as no mitigation is proposed disturbance of benthos will remain negligible and **not significant**.

Direct impacts on benthos due to habitat disturbance/loss

11.261. Maintenance of sub-stations within the Project Alpha and Project Bravo areas may require the use of jack-up barges which would cause disturbance where they make contact with the seabed. Activities would be restricted to scheduled maintenance works or unexpected repairs. At present it is not possible to state how many events this is likely to be, however, for the Transmission Asset Project there will be a maximum of 5 OSPs for which there could be maintenance related impacts.

11.262. In addition to the maintenance activities to the OSPs scour holes will form around the foundations removing benthic habitat. These impacts have been assessed within the Project Alpha and Bravo sections above and were predicted to be negligible and **not significant**.

11.263. The export cables may also need maintenance work during the operation of the Transmission Asset Project, however these are likely to occur very occasionally if at all and therefore the impact is predicted to be negligible and **not significant**.

11.264. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

No mitigation measures are available for this impact.

Residual Impact

11.265. As no mitigation is proposed it is likely that impact of habitat disturbance of benthos will remain negligible and **not significant**.

Impact on benthos due to habitat creation

11.266. As discussed above for both Project Alpha and Project Bravo, the substructures/ foundations of structures will change the nature of the available habitat. Benthic species will rapidly colonise the new habitats and communities will be established on the hard substrata. Within the Transmission Asset the maximum number of OSPs (five) would provide the maximum amount of potential new habitat (Table 11.12c) available for colonisation.

11.267. The amount of new habitat created by these OSPs is relatively small compared with the amount of new habitat formed as part of the Project Alpha and Project Bravo where there are more structures. Therefore the magnitude of the impact (which was considered low in for Project Alpha and Project Bravo) will be far less and it is likely that the impact of habitat creation of the OSPs will be negligible and **not significant**.

11.268. The cable protection deployed to safeguard up to six export cables are likely to be, colonised by benthic species which could be expected to include seaweeds, mussels, barnacles, tubeworms, hydroids, sponges, soft corals, amphipods, anemones and other sessile invertebrates, as well as more mobile fauna including starfish and crabs, however the rate and sequence of colonisation is difficult to predict. It has been assumed that a maximum of 10% of the overall length of the cables will be protected by rock, mattresses or grout bags which will occupy an area of up to 7m in width. This will result in the creation of approximately 37.1ha (Table 11.12c) of new substrate.

11.269. Whilst there is potential for creation of new habitat from the ECR component of the Transmission Asset Project to benefit the marine community through colonisation of the cable protection, it is unlikely that these changes will result in any significant broad scale community or biodiversity changes and therefore the magnitude of the impact will be negligible.

11.270. It is difficult to predict which species will colonise the newly created habitat and therefore it is difficult to assign a sensitivity of the receptor; so a precautionary stance is taken and the sensitivity is considered as medium. It is considered that the impact of creation of new habitats within the ECR will be of negligible significance.

11.271. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation
No mitigation measures are available

Residual Impact

11.272. The residual impact of creation of new habitat is likely to be negligible and **not significant.**

Indirect impacts from alteration to human activities

11.273. As discussed for Project Alpha and Project Bravo above, there is potential for some exclusion of fishing activity from the wind farm sites which may have subsequent impacts to the benthic ecology. Within the Transmission Asset Project the magnitude of this impact will be far smaller than seen in Projects Alpha and Bravo and as it is only the presence of substations that will impact upon fisheries therefore the significance of this impact is considered negligible and **not significant**.

11.274. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

No mitigation measures are advised

Residual Impact

11.275. As no mitigation is advised the indirect impacts of alteration of human activities as a result of the Transmission Asset Project infrastructure will remain of negligible and **not significant**.

Direct impacts on intertidal ecology due to maintenance activities

11.276. Impacts on the intertidal zone during operation are considered unlikely unless there is a need to carry out emergency maintenance work on the export cables.

11.277. No sensitive communities have been identified in the intertidal zone at the Landfall site; therefore the sensitivity of the community is considered to be low. Maintenance activities on cables will be rare and works will be limited to the area needed to excavate and repair any faulty cable and be temporary. Therefore the magnitude of any impact will be low. Consequently it is considered that the impacts to intertidal ecology will be negligible and **not significant**.

11.278. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

No mitigation measures are available

Residual Impact

11.279. The residual impact on intertidal ecology due to maintenance activities likely to be negligible and **not significant**.

IMPACT ASSESSMENT – DECOMMISSIONING

11.280. The Project Alpha and Project Bravo operators and the appointed OFTO will be required to prepare detailed decommissioning plans at the request of Scottish Ministers. These plans will cover the methodology for when and how the Projects will be decommissioned.

Project Alpha

Impacts on benthos

11.281. It is currently envisaged that during decommissioning of Project Alpha any piled foundations will be cut below seabed level (using methods such as abrasive water jet cutter or diamond wire cutting) with the protruding section being removed. Complete removal of driven piles is not expected to be practical or desirable. The use of explosives in removing the piles is likely to be discounted due to the potential impacts to the environment, in particular marine mammals.

11.282. It may be preferable to leave gravity base foundations on the seabed to preserve the marine habitat that has established over their life, subject to discussions with key stakeholders and depending on the regulations in place at the time. However, if removal is required the ballast will be removed and the GBS refloated. It will then be towed to an approved destination for recycling or disposal as appropriate (see Chapter 5: Project Description).

11.283. With regard to cables, again a decision will be made at the appropriate time, however it is currently considered likely that cables and any cable protection will be left in situ. It is also considered likely that scour protection around foundations would be left in situ.

11.284. Decommissioning impacts will be similar to those described for the construction phase (physical disturbance, habitat loss, increased suspended sediments and re-mobilisation of contaminants); although these are likely to be lower in magnitude (as a proportion of the infrastructure is likely to be left in situ). Given the low or medium sensitivity of the habitats in the area and the low magnitude of impact, the significance of the impact of decommissioning overall would be minor adverse to negligible and **not significant**.

11.285. In addition, any complex habitats have developed on the hard substrate provided by the infrastructure will be lost when infrastructure is removed. Over time the original habitats lost in the footprint of the infrastructure will redevelop. The long term effect of this would be to return the area to its former state and the impact would be neutral with no impact on the long term.

11.286. There is potential that sensitive features not currently present (for example biogenic reefs) may develop within the Project Alpha area during the operational period. If such features have developed, it will be necessary to discuss how to decommission the wind farm with the regulators. From a precautionary standpoint, therefore, there may be minor adverse and **not significant** impacts during the decommissioning phase.

11.287. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

It is anticipated that surveying for Annex I habitat will be undertaken prior to decommissioning as part of the agreed Decommissioning Plan. Should these surveys indicate the presence of any sensitive habitats the applicants will discuss how to decommission the wind farm with the regulators to avoid, where possible, impacts upon such habitats.

Residual Impact

11.288. In light of such mitigation measures the residual impact on the benthos from decommissioning will be negligible and **not significant**.

Project Bravo

Impacts on benthos

11.289. As the decommissioning plan for Project Bravo is likely to be similar to that of Project Alpha and the benthos across both sites is largely similar the same impacts are likely to occur across both sites. As discussed above in the potential impacts on the benthos as a result of decommissioning the predicted to be at worst minor adverse and **not significant**.

11.290. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

It is anticipated that surveying for Annex I habitat will be undertaken prior to decommissioning as part of the agreed Decommissioning Plan. Should these surveys indicate the presence of any sensitive habitats the applicants will discuss how to decommission the wind farm with the regulators to avoid, where possible, impacts upon such habitats.

Residual Impact

11.291. In light of such mitigation measures the residual impact on the subtidal benthos from decommissioning will be of negligible significance.

Transmission Asset Project

Potential Impacts on benthos

11.292. An outline of the decommissioning processes is presented in Chapter 5: Project Description. The expected impacts of the decommissioning of Project Alpha and Project Bravo are detailed above. The type of impacts of decommissioning the OSPs within the wind farms which are part of Transmission Assets Project will be similar in nature but due to decreased scale (up to 5 structures being decommissioned rather than 81) the magnitude of the impacts will be greatly reduced. Therefore the magnitude of the impact will be negligible resulting in impacts of negligible significance.

11.293. Discussions will be held with stakeholders and regulators to determine if cables will be left in situ if considered appropriate, or wholly or partially removed. Throughout the project life-cycle, the burial depth will be closely monitored. Feasible methods for cable removal include pulling the cable out of the seabed using a grapnel, pulling an under-runner using a steel cable to push the electrical cable from the seabed, or jetting the seabed material (see Chapter 5: Project Description).

11.294. The magnitude of the impact of cable removal will be at worst the same as that for construction which was predicted to be low. The sensitivity of the habitats likely to be affected cannot be determined at this stage as it is not known what will colonise the cable protection therefore a precautionary stance must be taken and sensitivity is considered to be medium. Therefore the potential impacts on the benthos due to decommissioning of the ECR are considered to be minor adverse and **not significant**.

11.295. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

It is anticipated that surveying for Annex I habitat will be undertaken prior to decommissioning in line with those anticipated prior to construction. Should these surveys indicate the presence of any sensitive habitats, the applicants will discuss how to decommission the wind farm with the regulators to avoid, where possible, impacts upon such habitats.

Residual Impact

11.296. The residual impact on the benthos from decommissioning is likely to remain at negligible and **not significant**.

Potential impacts on intertidal ecology

11.297. It is expected that burial depth will be an important factor in helping to determine the appropriate course of action for removal of cables in the intertidal area. This will therefore be closely monitored throughout the project life-cycle. The removal of all intertidal cabling will result in impacts on intertidal ecology in line with those specified for construction. Given the uniform nature and recoverability of the communities present, the intertidal habitats at the landfall site are considered to have low sensitivity and the fact that a small area of intertidal environment is likely to be disturbed by cable removal a low magnitude of impact is predicted. It is therefore anticipated that the impacts on intertidal ecology will be negligible and **not significant**. If cables are left in situ there will be no impact.

11.298. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Mitigation

Mitigation

No mitigation measures are available

Residual Impact

11.299. As no mitigation measures are available the impacts of decommissioning on intertidal ecology will remain negligible and **not significant** if cables are removed. There will be no impact if cables are left in situ.

IMPACT ASSESSMENT – CUMULATIVE AND IN-COMBINATION

11.300. In addition to identifying the potential impacts of Project Alpha, Project Bravo and the Transmission Asset Project on benthic ecology in isolation, this section considers the cumulative impacts of the elements of the Seagreen Project together firstly and then with other existing, consented and / or proposed development / activity in the Firth of Forth region and beyond.

Cumulative Impacts

11.301. It is important to draw together the impacts considered for each of the individual projects, so that the development of the Seagreen Project can be seen in terms of its cumulative impacts on benthic ecology. Table 11.20 below provides detail of the main cumulative impacts that will occur as a result of Project Alpha, Project Bravo and the Transmission

asset. The table collates information regarding each element and provides a total which is the summation of all the various elements.

11.302. Potential cumulative impacts within the Seagreen Project include:

- disturbance of habitat;
- loss of habitats; and
- habitat creation;

11.303. The cumulative effects of these impacts are presented in Table 11.17

Disturbance of habitat

11.304. The maximum cumulative area that will be disturbed as part of the construction of Project Alpha, Bravo and Transmission Asset Project is 1,546.38ha. This area represents just 3.2% of the total area within the Seagreen Project boundary (Table 11.17). This impact will however be temporary and therefore the magnitude of disturbance is considered low.

11.305. The sensitivity of the habitats to disturbance impacts are considered to be low to medium (Tables 11.12, 11.13 and 11.14). Therefore it is likely that the cumulative impact of the Seagreen Project will be minor adverse and **not significant**.

11.306. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Habitat Loss

11.307. The maximum cumulative area of habitat that will be lost due to the construction of Project Alpha, Project Bravo and the Transmission Asset Project is 218.41ha. This area represents just 0.4% of the total area within the Seagreen Project boundary (Table 11.17). This impact will be permanent lasting for the duration of the Seagreen Project lifespan. However, given the extent of the seabed impacted, the magnitude of habitat loss is considered negligible.

11.308. Due to the large areas identified for each habitat type across the ISA (Figure 11.5 and 11.9) and the fact that of the habitats for which an assessment is available are of no more than medium sensitivity to habitat loss, the cumulative impact of habitat loss due to the Seagreen project is considered negligible and **not significant**.

11.309. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Table 11.17 Cumulative impacts of Seagreen projects (Alpha, Bravo, Transmission Asset)

Impact	Project Alpha	Project Bravo	Transmission Asset Project	Cumulative Impact	Justification
Construction					
Disturbance of habitat	Negligible	Negligible	Minor adverse	Total area of disturbance 1,546.38ha This equates to 3.2 % of the overall consent area and is considered minor adverse	Sum total of area of disturbance of the worst case scenarios of all three elements
Loss of habitat	Minor adverse	Minor adverse	Minor adverse	Total area of habitat loss 218.41ha This equates to 0.4% of the overall consent area which is considered negligible	Sum total of area of habitat loss of the worst case scenarios of all three elements.
Operation					
Habitat creation	Negligible	Negligible	Negligible	Total area of habitat created will be in excess of 218.41ha which is considered to be negligible	This is the equivalent to the sum total of habitat in all cases. Habitat is lost when a structure is placed on the seabed therefore creating new habitat. The eventual increase in area available for colonisation by benthic species will be greater than this due to the three dimensional nature of the structures.
Decommissioning					
Disturbance of habitat	Minor adverse	Minor adverse	Negligible to Minor adverse	Total area of disturbance 1,546.38ha This equates to 3.2% of the overall consent area which is considered minor adverse	Without a decommissioning plan it is difficult to assess the magnitude of impact likely to be caused by decommissioning so it has been assumed that they will be similar to that experienced during construction.

Creation of Habitat

11.310. An area approximately the size of the area of habitat loss will be created during the construction and operation phases of the Seagreen Project and therefore, given the spatial extent of this, the magnitude of the impact is considered to be negligible and **not significant**.

11.311. The new substrate will be very different from the existing substrate and the species that colonise it are also likely to differ. It is very difficult to predict what species will colonise the new habitats and as a result it is difficult to assign a sensitivity level to this impact, therefore from a precautionary standpoint the sensitivity of the benthos to this change is considered to be medium. Consequently the cumulative impact of the creation of new habitats created by the Seagreen Project is likely to be of negligible significance.

11.312. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Disturbance of habitat through decommissioning of the Seagreen project

11.313. It is expected that the impacts caused during decommissioning of the Seagreen Project will be equivalent to (or less than) the magnitude of those seen during construction (see cumulative impact 1 above); therefore the magnitude of disturbance is considered low. However, the sensitivity of the benthic communities which will be present at the time of decommissioning cannot be predicted at the present time. Therefore, from a precautionary standpoint the sensitivity of the benthos is considered to be medium. A decommissioning plan will be completed prior any removal of structures from the seabed. It is assumed that the decommissioning plan will take into consideration all appropriate methodologies which will minimise impacts to benthic ecology at that time. Using Table 11.5 it is predicted that the impact of disturbance of habitat through decommissioning of the Seagreen project will be minor adverse and **not significant**.

11.314. Given that site specific data has been collected and the effects on the habitats are well known there is a high degree of confidence that the resultant impacts will not exceed those predicted.

Seagreen cumulative impact with other schemes

11.315. The main cumulative impacts to the benthos are likely to be:

- direct loss of seabed habitat and changes in community structure; and
- introduction of new substrate (due to scour protection, mattressing etc.) and potential reef effects

11.316. Given the lack of other industries in the region (see Chapter 20: Other Marine Users and Activities) there are few activities or developments that could have a cumulative impact upon the benthos. In addition, impacts upon the benthos will be highly localised and there is little likelihood of interaction of impact. Therefore, cumulative impacts considered here are with regard to loss of habitat and disturbance and are considered as additive impacts within the wider Firth of Forth and Firth of Tay region in the vicinity of the Seagreen Project. Two other OWFs are currently in the planning process and are considered relevant in terms of cumulative impact; these are the Inch Cape Offshore Wind Farm (Inch Cape) and Neart na Gaoithe Offshore Wind Farm (Neart na Gaoithe) which will both be located inshore of the Seagreen project. Inch Cape will be located approximately 10km west of Project Alpha and Neart na Gaoithe will be located approximately 30km south west.

11.317. With regard to construction impacts, these will only occur for those projects for which construction will overlap with that of the Seagreen Project. Most of the potential impacts (physical disturbance, increases in suspended sediments and changes to tidal current regime) will be temporary, small scale and localised for the Seagreen project and this will be the case with other projects therefore there is no potential for this impacts to manifest cumulatively across the various schemes.

Habitat loss (multiple schemes)

11.318. The maximum cumulative area of habitat that will be lost due to the construction of the Seagreen Project, Inch Cape and Neart na Gaoithe is 485ha (Table 11.18). When placed in context of the combined size of the areas under application for consent it represents approximately 0.25%. This impact will be permanent lasting for the duration of the projects. The magnitude of cumulative habitat loss is considered negligible.

11.319. It is not currently known what species or habitats occur across the Inch Cape site, therefore the Mapping European Seabed Habitats (MESH) on line interactive map[7] has been used to indicate which habitats may exist across this site (MESH, undated). The habitats predicted within Inch Cape site include 'deep circalittoral coarse sediments' which are characterised by robust infaunal polychaete and bivalve species and occur over large areas of the offshore continental shelf, as well as 'deep circalittoral sand' which is characterised by sands or non-cohesive muddy sands and are likely to support a diverse range of polychaetes, amphipods, bivalves and echinoderms (Connor *et al*., 2004).

11.320. The assessment of habitat loss within the Neart na Gaoithe concluded that, although the habitats across the site had varying degrees of tolerance to habitat loss the magnitude of the impact would be low and therefore not significant (Mainstream, July 2012).

11.321. The area of habitat loss that would occur if all three projects are consented will represent approximately 0.25% of the total area under application for consent. The magnitude of the impact is therefore likely to be negligible. However, a precautionary standpoint should be taken as data is not available for Inch Cape and therefore the sensitivity of the receptor is considered to be medium. Consequently, the cumulative impact of habitat loss caused by the three wind farms is considered to be negligible and **not significant**.

7 http:/ / www.searchmesh.net/

Table 11.18 Cumulative impacts of the Seageen Project, Inch Cape and Neart na Gaoithe all units provided in hectares (ha) unless otherwise stated

	Seagreen	Inch Cape	Neart na Gaoithe	Cumulative	Justification
Construction					
Habitat Loss	Total Area of Habitat loss 218.41ha (see Table 11.17). Impact assessed as negligible significance.	Environmental statement not available at time of writing. WTG GBS + scour: 208.78 Substation: 22.5 Export Cable that is protected*: 5.25 array cable details not available Met Mast: 2.19 Total: 238.72 Impacts not assessed at time of writing however significance is likely to minor adverse at worst.	Total Area of Habitat loss calculated to be 28ha. Impact assessed as of Minor significance (Mainstream, July 2012)	The total of all three wind farms is 480.33ha which equates to 0.25% of the total consent area	The area of Habitat loss as a percentage of the overall area for which consent applications are being made is very small. Although the assessment of habitat loss at the Inche Cape site is unavailable at the time of writing. it is unlikely that impacts at the individual wind farms will any worse than minor adverse and therefore the cumulative impact is unlikely to amount to anything greater then minor significance.
Operation					
Habitat creation	The area of new habitat created will be almost proportional to the area of habitat lost	The area of new habitat created will be almost proportional to the area of habitat lost	The area of new habitat created will be almost proportional to the area of habitat lost	The total of all three wind farms is 480.33ha which equates to 0.25% of the total consent area	This is the equivalent to the sum total of habitat in all cases habitat is lost when a structure is placed on the seabed therefore creating new habitat. The eventual increase in area available for colonisation by benthic species will be greater than this due to the three dimensional nature of the structures, however calculating this precise area would be complex and unlikely to lead to a realistic outcome.

Habitat creation (multiple schemes)

11.322. An area approximately the size of the area of habitat loss will be created by construction and through operation of the Seagreen Project, the Inch Cape Project and the Neart na Gaoithe Project cumulatively (Table 11.18) and therefore the magnitude of the impact can be considered negligible (see above).

11.323. The newly created substrate will be very different from the existing substrate and the species that colonise it are also likely to differ. It is difficult to predict what species will colonise the new habitats and as a result it is difficult to assign a sensitivity level to this impact so from a precautionary standpoint the sensitivity category of medium is used. Consequently, the cumulative impact of the creation of new habitats created by the Seagreen Project cumulatively is likely to be negligible and **not significant**.

11.324. Given the lack of detailed benthic data for the other sites and that magnitude of impact is based on design parameters that may have changed there is only a medium degree of confidence that the resultant impacts will not exceed those predicted.

Seagreen cumulative impact including Phases 2 and 3

11.325. Seagreen Phases 2 and 3 encompass five potential offshore wind farm sites and connection to the National Grid via three export cable routes running from the south-western boundary of the Round 3 Zone and coming together at a single landing point near Torness (according to current connection agreements at time of writing). Connection agreements, which are in place, indicate that the power generated is to be connected to the electricity transmission network at a location near Branxton, East Lothian. Phases 2 and 3 are planned to have a combined output target of 2.6 GW.

11.326. It is anticipated that applications for the necessary consents for development of wind farm sites within Phase 2 and Phase 3 will be submitted in 2014 and 2016 respectively. The applicants believe that the design and development within Phases 2 and 3 of the Zone must be adaptive and take into account the lessons learned from both Round 1 and Round 2 offshore wind farm projects that have gone through the consenting and construction processes, alongside lessons from the Seagreen Project (as discussed in this ES) and other projects currently under development in the Scottish Territorial Waters (STW).

11.327. The status of Phases 2 and 3 is that a scoping exercise has been undertaken (Seagreen, 2011) based upon current best-available evidence for those areas. It is anticipated that further detailed work will be undertaken in the period leading up to submission of applications for the necessary consents in 2014 and 2016. Such work will include:

- detailed geophysical work to determine the surface topography and underlying geology of the Phases;
- physical process modelling once detailed design information is available to determine likely effects of Phases 2 and 3;
- benthic survey (grabs, trawls and video sampling) designed with regard to the results of the geophysical survey to determine the nature of the benthic community, composition of surface sediments and presence of any contaminants; and
- desk based assessment and some site specific survey to determine the baseline conditions of the human environment.

11.328. From the above, it can be seen that large amounts of data relevant to Phases 2 and 3 have yet to be analysed or have yet to be collected. Any assessment of the baseline for these Phases would therefore be assigned a low level of confidence if included in this ES.

11.329. There have been considerable changes to the original design and location of the Phase 1 projects during the detailed development work as environmental concerns (both ecological and human) have emerged that have shaped the projects going forward within the EIA. Given the size of the Zone and the development process Seagreen intends to follow, an optimal layout and approach will be developed in order to deliver as close to the target power output (3.7GW) as possible without causing a significant impact upon the receiving environment and in particular European sites and species. The applicant will consider the use of all areas within the Zone not necessarily restricted to the Phase 2 and Phase 3 indicative boundaries. Seagreen are committed to progressing the development of Phases 2 and 3 in a way that avoids environmental impact where possible and in particular minimises cumulative environmental impacts as much as possible.

11.330. As a developer, Seagreen wishes to use best available evidence and best practice in order to follow a responsible approach to the development of Phases 2 and 3. Therefore, to a great extent, the design refinement for Phases 2 and 3 will be dependent upon the on-going process with regard to Phase 1, the STW sites and other offshore wind developments in Scotland. Given the data gaps and further work required cited above, any assessment of the baseline conditions of Phases 2 and 3 required for the cumulative assessment of the Seagreen Project would have to be assigned a low confidence level with regard to overall accuracy in particular with respect to capacity, developable area and layout. Given this, the Applicants do not consider that for this assessment it is reasonable to present detailed analysis of the potential impacts of Phases 2 and 3 for inclusion within this assessment.

11.331. For benthic ecology there is the potential for cumulative impact upon sensitive benthic habitats. For the Seagreen Project it is known that there are no high sensitivity habitats within the Project Alpha and Bravo sites or ECR corridor and therefore no significant cumulative impacts are likely as discussed above (11.300 to 11.314). In the absence of benthic survey for Phases 2 and 3, it is not known whether there are any high sensitivity habitats within them, however in line with the mitigation proposed for the Seagreen Project, any sensitive habitats would be avoided and therefore there will be no significant impacts. It is therefore assumed that the overall footprint of Phases 2 and 3 would be in proportionate to their scale, but given the ubiquity of habitats with medium or low sensitivity and the potential to avoid any habitat deemed sensitive, the magnitude of impact would be low. The significance of impacts from Phases 2 and 3 are therefore likely to be minor adverse to negligible and **not significant** and any cumulative impact is also therefore likely to be minor adverse to negligible and **not significant**.

ENVIRONMENTAL STATEMENT LINKAGES

11.332. The inter-relationships between the marine and intertidal ecology and other physical, environmental and human parameters are inherently considered throughout the assessment of impacts as a result of the receptor lead approach to the assessment. For example, marine ecology has the potential to be influenced by increases in suspended sediments as a result of effects on physical processes from the proposed development. The potential impacts as a result of this indirect effect have been discussed within this Chapter based on the findings of the assessments made in Chapters 7: Physical Environment and Chapter 8: Water and Sediment Quality.

Table 11.19 ES Linkages

Inter-relationship	Relevant section	Linked chapter
Indirect impacts on marine ecology from increased suspended sediments and or contaminants	Impact Assessment – Construction Phase Impact Assessment - Operation	Influencing parameter - Ch.7: Physical Environment and Ch.8: Water and Sediment Quality Affected parameter – Ch.10: Ornithology, Ch.12: Natural Fish and Shellfish Resource
Indirect impacts on marine ecology and habitat from changes to physical processes	Impact Assessment – Operation	Influencing parameter – Ch.7: Physical Environment Affected parameter – Ch.10: Ornithology, Ch.12: Natural Fish and Shellfish Resource
Indirect impact on intertidal ecology from changes in coastal processes	Impact Assessment – Operation	Influencing parameter - Ch.7: Physical Environment
Indirect impacts on marine ecology from changes in human activity	Impact Assessment – Operation	Influencing parameter – Ch.15: Commercial Fisheries Affected parameter – Ch.10: Ornithology, Ch.12: Natural Fish and Shellfish Resource

OUTLINE MONITORING

11.333. Seagreen is committed to development of a post construction monitoring plan, if appropriate and requested by the regulators.

11.334. Any monitoring program will be designed in consultation with Marine Scotland and SNH to ensure it collects suitable data to answer appropriate questions raised during the project consenting process. It is suggested that monitoring of, or sampling for, changes in benthic communities is unlikely to be necessary given the limited scale of potential impacts or sensitivity of impacted habitats or species.

SUMMARY

11.335. Tables 11.20a and 11.20b summarise the predicted significance of each impact assessed within the EIA, provide the suggested mitigation and the residual impact.

Table 11.20 a Summary of Project Alpha and Project Bravo Impacts

Description of Effect	Impact	Potential Mitigation Measures	Residual Impact
Construction Phase			
Direct impact on benthos due to physical disturbance	Negligible and **not significant**	Siting of WTG, array cables and ancillary structures to avoid the areas of sensitive habitat where ever practicable. As part of the pre-construction survey (which will be agreed with Marine Scotland) data will be analysed to ascertain the presences of any rare or important habitats, such as *Sabellaria* or *Modiolus* reefs and microsite infrastructure if necessary	Negligible and **not significant**
Direct impact on benthos due to the loss of habitat	Minor adverse and **not significant** (Alpha) Negligible and **not significant** (Bravo)	Mitigation measures Siting of WTG, array cables and ancillary structures to avoid the areas of sensitive habitat where ever practicable. As part of the pre-construction survey (which will be agreed with Marine Scotland) data will be analysed to ascertain the presences of any rare or important habitats, such as *Sabellaria* or Modiolus reefs and microsite infrastructure if necessary	Negligible and **not significant**
Indirect impacts on benthos due to increased suspended sediments	Negligible and **not significant**	No mitigation measures are advised for this impact	Negligible and **not significant**
Indirect impacts on benthos through re-mobilisation of contaminated sediments	Negligible and **not significant**	No mitigation measures are advised for this impact	Negligible and **not significant**
Operation Phase			
Direct impact on benthos due to physical disturbance caused by maintenance activities	Negligible and **not significant**	No mitigation measures are advised for this impact	Negligible and **not significant**
Direct impacts on subtidal benthos due to creation of new habitat	Negligible and **not significant**	No mitigation measures are advised for this impact	Negligible and **not significant**
Indirect impacts on benthos due to changes in current regime and coastal processes	Negligible and **not significant**	No mitigation measures are advised for this impact	Negligible and **not significant**
Indirect impacts on subtidal benthos due to alteration to existing human activity	Negligible and **not significant**	No mitigation measures are advised for this impact	Negligible and **not significant**
Decommissioning Phase			
Impacts on benthos	Minor adverse and **not significant**	It is anticipated that surveying for Annex I habitat will be undertaken prior to decommissioning in line with surveys anticipated as part of the pre-construction activities (see Assessment of Impacts – Worst Case Scenario). Should these surveys indicate the presence of any sensitive habitats. Seagreen will discuss how to decommission the wind farm with the regulators to avoid, where possible, impacts upon such habitats.	Negligible and **not significant**

Table 11.20b Summary of Transmission Asset Project Impacts

Description of Effect	Impact	Potential Mitigation Measures	Residual Impact
Construction Phase			
Direct physical disturbance of subtidal benthic species and habitats	Minor adverse and **not significant**	Where possible the cable route should aim to avoid the more sensitive habitats (Table 11.11) and where this is not possible the route should take the shortest distance possible through the sensitive areas.	Negligible and **not significant**
Direct impact on benthos due to the loss of habitat	Minor adverse and **not significant**	Localised habitat loss during the cable installation is an unavoidable consequence of the Seagreen Project. Best practice guidance will be followed to ensure that potential habitat loss is minimised throughout the proposed works. The amount of rock, grout bags or mattresses used to protect the cable will be kept to the minimum amount (which may be less than the worst case estimate of 10% of the ECR) necessary to ensure protection.	Negligible and **not significant**
Indirect impacts on benthos due to increased suspended sediments	Negligible and **not significant**	Short-term and localised changes to sediments and sedimentary structures during the construction phase of the proposed works are an unavoidable consequence of the Seagreen Project. Best practice guidance will be followed to ensure that potential damage to environmental features is minimised throughout the proposed works.	Negligible and **not significant**
Direct impact on intertidal ecology due to physical disturbance	Negligible and **not significant**	Best practice measures will be employed by Seagreen, based on lessons learnt from equivalent cable installations across sandy shores, to ensure that the significance of potential impacts remain as negligible, these include: • Limiting the number of vehicle operations across the intertidal area. • Ensuring that any vehicle operations keep to designated areas of minimal practicable size • Lay down of tracking if appropriate in areas of softer sand.	Negligible and **not significant**
Effects on Nature Conservation designations	Negligible and **not significant**	Short-term and localised changes to sediments and sedimentary structures during the construction phase of the proposed works are an unavoidable consequence of the Seagreen Project. Best practice guidance will be followed to ensure that potential damage to environmental features is minimised throughout the proposed works.	Negligible and **not significant**
Operation Phase			
Increased suspended sediments and mobilisation of contaminants leading to smothering of benthic ecology	Negligible and **not significant**	No mitigation measures are available for this impact.	Negligible and **not significant**

Description of Effect	Impact	Potential Mitigation Measures	Residual Impact
Direct impacts on benthos due to habitat disturbance/ loss	Negligible and **not significant**	No mitigation measures are available for this impact.	Negligible and **not significant**
Impact on benthos due to habitat creation	Negligible and **not significant**	No mitigation measures are available	Negligible and **not significant**
Indirect impacts from alteration to human activities	Negligible and **not significant**	No mitigation measures are available	Negligible and **not significant**
Direct impacts on intertidal ecology due to maintenance activities	Negligible and **not significant**	No mitigation measures are available	Negligible and **not significant**
Decommissioning Phase			
Potential Impacts on benthos	Minor adverse and **not significant**	It is anticipated that surveying for Annex I habitat will be undertaken prior to decommissioning in line with those anticipated pre-construction (see Section Assessment of Impacts – Worst Case Scenario). Should these surveys indicate the presence of any sensitive habitats, the applicants will discuss how to decommission the wind farm with the regulators to avoid, where possible, impacts upon such habitats.	Negligible and **not significant**
Potential impacts on intertidal ecology	Negligible and **not significant**	No mitigation measures are available	Negligible and **not significant**

REFERENCES

Bacchiocchi, F and Airoldi, L. (2003). *Distribution and dynamics of epibiota on hard tructures for coastal protection*. Estuarine, Coastal and Shelf Science 56 (2003) 1157–1166

Bio/ Consult (2004). *Hard Bottom Substrate Monitoring Horns Rev Offshore Wind Farm Annual Status Report* 2003. Report to Elsam Engineering Ltd, published May 2004

Boyd, S.E. (2002). *Guidelines for the conduct of benthic studies at aggregate dredging sites*. Department for Transport, Local Government and the Regions (DTLR)/ CEFAS: London, UK. 117 pp

Clark, R.B. (1997) "*Marine Pollution*", Clarendon Press, 1997

Connor, D.W., Allen, J.H., Golding, N., Howell,K.I., Lieberknecht, L.M., Northern, N. and Reker, J.B. (2004). The *Marine Habitat Classification for Britain and Ireland Version* 04.05. JNCC, Peterborough ISBN 1 861 07561 8 (internet version). Available at URL: www.jncc.gov.uk/ MarineHabitatClassification. Accessed 10/ 10/ 2011

Daan, R., Mulder, M. and Bergman, M. J. N (2009). Imp*act of windfarm OWEZ on the local macrobenthos community Koninklijk Nederlands Instituut voor Zeeonderzoek* (NIOZ) Report

Davies, J., Baxter, J., Bradley, J., Connor, J., Khan, J,, Murray, E., Sanderson, J., Turnbull, C. and M. Vincent (2001). *Marine Monitoring Handbook*, JNCC

Department of Environment Food and Rural Affairs (Defra) (2004) *Review of Marine Nature Conservation*, Working Group report to Government

Durkin, O.C. (2008). *Moerella spp. with venerid bivalves in infralittoral gravelly sand. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at URL: <http:/ / www.marlin.ac.uk/ habitatsensitivity.php?habitatid=388&code=2004>. Accessed: 24/ 03/ 2012.

Dyer, M.F., Fry, W.G, Fry, P.D and Cranmer, G.J (1982). A *series of North Sea benthos surveys with trawl and headline camera*. Journal of the Marine Biological Association of the United Kingdom, 62 , pp 297-313

Eleftheriou, A., Basford, D. and Moore D. C. (2004). *Synthesis of Information on the Benthos of Area SEA 5*. Available at URL: http:/ / www.offshore-sea.org.uk/ consultations/ SEA_5/ SEA5_TR_Benthos_Elef.pdf Accessed 24/ 03/ 2012

Emu (2006). *Kentish flats Offshore Windfarm Post-Construction Swath Survey 3*. Report No. 06/ J/ 1/ 0942/ 0590 to Kentish Flats Limited

Emu (2008). *Kentish Flats Offshore Wind Farm Turbine Foundation Faunal Colonisation Diving Survey*. Report No 08/ J/ 1/ 03/ 1034/ 0839 Final November 2008.

Engel J. & Kvitek R. (1998). *Effects of otter trawling on a benthic community in monterey bay national marine sanctuary*. Conservation Biology, 12, 1204-1214.

Gubbay, S. (2007) *Defining and managing Sabellaria spinulosa reefs: report of an inter-agency workshop 1-2 May, 2007*. Joint Nature Conservation Committee Report No. 405. 22pp. JNCC, Peterborough. ISSN 0963-8091.

Hill, J.M. (2008). *Amphiura filiformis and Echinocardium cordatum in circalittoral clean or slightly muddy sand. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom.]. Available at URL: <http:/ / www.marlin.ac.uk/ habitatsensitivity.php?habitatid=368&code=2004>. Accessed 23/ 03/ 2012

Howson, C.M., Steel, L., Carruthers, M., Gillham, K. 2012. *Identification of Priority Marine Features in Scottish Territorial Waters*. Scottish Natural Heritage Commissioned Report. No. 388.

Jackson, A. Hiscock, K. (2008). *Sabellaria spinulosa. Ross worm. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at URL: www.marlin.ac.uk/ speciessensitivity.php?speciesID=4278. Accessed: 4/ 11/ 2011

Jennings S. & Kaiser M.J. (1998). *The effects of fishing on marine ecosystems. Advances in marine biology*, 34, 201-352.

Jennings, S., Lancaster, J., Woolmer, A., and Cotter, J., (1999). *Distribution, diversity and abundance of epibenthic fauna in the North Sea.* Journal of the Marine Biological Association of the United Kingdom, 79, 385 – 399.

Joint Nature Conservation Committee (2004) *Developing regional seas for UK waters using biogeographic principles*

Joint Nature Conservation Committee (2011). *Marine Habitat Classification Hierarchy* [cited 29/ 03/ 2011]. Available at URL: http:/ / jncc.defra.gov.uk/ page-1584. Accessed: 23/ 03/ 2012.

Joint Nature Conservation Committee (2012). *Identification of Priority Marine Features in Scotland's seas*. JNCC Report No. 462

Joint Nature Conservation Committee (undated). *Firth of Tay & Eden Estuary,* web page available at URL: http:/ / jncc.defra.gov.uk/ protectedsites/ sacselection/ sac.asp?EUcode=UK0030311 Accessed: 29/ 06/ 2012.

Joint Nature Conservation Committee, Scottish Natural Heritage and Marine Scotland (2012). *Identification of additional MPA search locations and discussions of search feature sensitivities: A guide to the 4th national MPA stakeholder workshop*

Kaiser M.J., Hill A.S., Ramsay K., Spencer B.E., Brand A.R., Veale L.O., Prudden K., Rees E.I.S., Munday B.W., Ball B. & Hawkins S.J. (1996). *Benthic disturbance by fishing gear in the Irish Sea: A comparison of beam trawling and scallop dredging.* Aquatic Conservation-Marine and Freshwater Ecosystems, 6, 269-285.

Langhamer, O., Wilhelmsson, D. and Engstrom, J. (2009). *Artificial reef effect and fouling impacts on offshore wave power foundations and buoys – a pilot study. Estuarine*, Coastal and Shelf Science 82 (2009) 426–432

Limpenny, D.S., Foster-Smith, R.L., Edwards, T.M., Hendrick, V.J., Diesing, M., Eggleton, J.D., Meadows, W.J., Crutchfield, Z., Pfeifer, S. and Reach, I.S., (2010). *Best methods for identifying and evaluating Sabellaria spinulosa and cobble reef. Natural England*, Supported through Defras Aggregates Levy Sustainability Fund

Lindeboom, H.J., Kouwenhoven ,H.J., Bergman M.J.N., Bouma, S., Brasseur,S., Daan, R., Fijn R.C., de Haan. D., Dirksen S., van Hal R., Hille Ris Lambers R., ter Hofstede. R, Krijgsveld K.L, Leopold M. and Scheidat (2011). *Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation*. Environmental Research Letters 035101 (13pp)

Mainstream ES submission, July 2012

Marine Ecological Surveys Limited (MES) (2007). *Predictive framework for assessment of recoverability of marine benthic communities following cessation of aggregate dredging. Technical Report to the Centre for Environment*, Fisheries and Aquaculture Science (CEFAS) and the Department for Environment, Food and Rural Affairs (Defra). Project No MEPF 04/ 02. Marine Ecological Surveys Limited, 24a Monmouth Place, Bath, BA1 2AY.

Marine Scotland (2011) *MPA search locations overview* 26th and 27th October 2011 Heriot-Watt University, Edinburgh

Marshall, C.E. (2008a). *Polychaete-rich deep Venus community in offshore mixed sediments. Marine Life Information Network: Biology and Sensitivity Key Information S*ub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at URL:www.marlin.ac.uk/ habitatsensitivity.php?habitatid=383&code=. Accessed: 24/ 03/ 2012

Marshall, C.E. (2008b). *Sabellaria spinulosa and Polydora spp. on stable circalittoral mixed sediment. Marine Life Information Network: Biology and Sensitivity Key Information* Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at URL: <http:/ / www.marlin.ac.uk/ habitatsensitivity.php?habitatid=22&code=2004> Accessed: 24/ 03/ 2012

Marshall, C.E. (2008c). *Mysella bidentata and Thyasira spp. in circalittoral muddy mixed sediment. Marine Life Information Network: Biology and Sensitivity Key Information* Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom]. Available at URL: www.marlin.ac.uk/ habitatsensitivity.php?habitatid=374&code. Accessed: 25/ 03/ 2012

Mapping European Seabed Habitats (MESH), (undated). *Mapping European Seabed Habitats.* Available at URL: http:/ / www.searchmesh.net. Accessed: 09/ 07/ 2012.

Mirto, S. and Danovaro, R. (2004). *Meiofaunal colonisation on artificial substrates: a tool for biomonitoring the environmental quality on coastal marine systems*. Marine Pollution Bulletin 48 (2004) 919–926

OSPAR Commission (2008) *Case Reports for the OSPAR List of threatened and/or declining species and habitats.*

Proudfoot, R.K., Elliot, M., Dyer, M.F., Barnett, B.E., Allen, J.H., Proctor, N.L., Cutts, N.D., Nikitik, C., Turner, G., Breen, J., Hemmingway, K.L. and Mackie, T. (1997). *Proceedings of the Humber benthic field methods workshop, Hull University 1997. Collection and processing of macrobenthic samples from soft sediments; a best practice review*. Environment Agency R&D Technical report E1-116, 50pp.

Rayment, W.J. (2008). *Fabulina fabula and Magelona mirabilis with venerid bivalves in infralittoral compacted fine sand. Marine Life Information Network: Biology and Sensitivity Key Information* Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at URL: www.marlin.ac.uk/ habitatsensitivity.php?habitatid=142&code=2004. Accessed: 24/ 03/ 2012

Royal Haskoning (2010a). *Scottish Territorial Waters Offshore Wind Farms - East Coast*. Discussion Document - Cumulative Effects

Royal Haskoning (2010b). *Scottish Offshore Wind Farms – East Coast:* Discussion Document (2) – Approach to Cumulative Effects Assessment

RWE, SSE and Royal Haskoning (2011*) Galloper Wind Farm Project:* Environmental Statement

Saunders, G., Bedford, G.S., Trendall, J.R., and Sotheran, I. (2011). *Guidance on survey and monitoring in relation to marine renewables deployments in Scotland. Volume 5. Benthic Habitats*. Unpublished draft report to Scottish Natural Heritage and Marine Scotland.

Schöne, B.R., Fiebig, J., Pfeiffer, M., Gleβ, R., Hickson, J., Johnson, A.L.A., Dreyer, W., Oschmann, W. (2005). *Climate records from a bivalved Methuselah (Arctica islandica, Mollusca; Iceland*). Palaeogeogr. Palaeoclimatol. Palaeoecol 228, 130-148.

Stenberg C., van Deurs M., Støttrup J., Mosegaard H., Grome T., Dinesen G, Christensen A., Jensen H, Kaspersen M, Willestofte Berg C, Leonhard S.B., Skov H., Pedersen J., Hvidt C.B. and Klaustrup M (2011). *Effect of the Horns Rev 1 Offshore Wind Farm on Fish Communities Follow-up Seven Years after Construction* DTU Aqua Report No 246-2011

Thrush S.F. & Dayton P.K. (2002). *Disturbance to marine benthic habitats by trawling and dredging: Implications for marine biodiversity*. Annual Review of Ecology and Systematics, 33, 449-473.

Tyler-Walters, H., Lear, D., Allen, J (2004) *Identifying offshore biotope complexes and their sensitivities Integrated Science for Integrated Management – Developing the capacity for adaptive ecosystem management*: Report to Centre for Environmental, Fisheries and Aquaculture Sciences (CEFAS) available at URL: www.marlin.ac.uk/ PDF/ Cefas_Rpt_revised.pdf. Accessed 24/ 032012