10 WIND FARM BENTHIC ECOLOGY

10.1 INTRODUCTION

1. This Section of the ES evaluates the likely significant effects of the Wind Farm on benthic ecology. The assessment has been undertaken by CMACS Ltd and includes an assessment of cumulative effects.

2. This Section of the ES is supported by the following documents:

- Annex 10A – Wind Farm Benthic Ecology Technical Report.

3. This Section includes the following elements:

- Assessment Methodology and Significance Criteria;
- Baseline Conditions;
- Development Design Mitigation;
- Assessment of Potential Effects;
- Mitigation Measures and Residual Effects;
- Monitoring and Enhancement;
- Summary of Effects;
- Assessment of Cumulative Effects;
- Statement of Significance; and
- References.

10.1.1 POLICY AND PLANS

4. The assessment takes into account the following guidelines.

- SEA of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters: Volume 1. Environmental Report (Marine Scotland, 2010);
- Guidelines for Ecological Impact Assessment in Britain and Ireland. Marine and Coastal (IEEM, 2010); and
- Centre for Environment Fisheries and Aquaculture (CEFAS) Guidance Note for Environmental Impact Assessment in Respect of the FEPA and CPA Requirements (CEFAS, 2004).

10.2 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

10.2.1 CONSULTATION

5. Survey methods, including number and position of samples, as well as sampling and analysis methods, were agreed in advance with Marine Scotland, SNH and the Crown Estate. Cumulative assessment methods were scoped with a wide variety of consultees. Comments received and the project response is given in Table 10.1. The detailed benthic ecology technical report, which presents the findings of the site characterisation surveys, was presented in draft to Marine Scotland and SNH for comment prior to preparing this assessment. These consultees were also contacted for sources of existing information, particularly regarding PMFs. Minor comments were received from both which were addressed as shown in Table 10.2.

Table 10.1 Summary of Consultation Responses Received on Cumulative Assessment (Benthic Ecology)

Consultee	Summary of Consultation Response	Project Response
RSPB	The EIA process should take into account any potential marine SPAs or offshore SACs and any future Marine Protected Areas.	Possible effects of the project on potential SPAs, SACs and Marine Protected Areas were considered, although no likely effects on benthos in any of these were identified.
SNH/JNCC	We welcome the intended liaison between consultancies with regard to benthic ecology (Section 4.3.1, page 27). This will be particularly important with regard to data-sharing and interpreting data in order to classify biotopes (Section 4.3.7, page 32). We therefore think that this liaison should be formalised with regard to biotope classification, so that it is agreed and recorded consistently across the two wind farm sites, and that any locations where there may be disagreement or differing interpretations of data are highlighted for further discussion and/or consultation with ourselves for advice.	CMACS and EMU continued to liaise closely in order to produce an agreed joint biotope map for the Beatrice and Moray Offshore Wind Farm study areas.
SNH/JNCC	In respect of Table 2.6.1 (pages 10 & 11) we recommend that military activities are also considered with regard to potential cumulative effects on benthic ecology.	Information on potential cumulative effects from military sources was sought although all potential sources identified were considered to be of negligible magnitude.

Table 10.2 Summary of Consultation Responses Received on Draft Benthic Technical Report

Consultee	Summary of Consultation Response	Project Response
MS	I have read through the CMACS technical report, it is well written and presented and contains just about everything I would expect for a survey of this type. I have a few short comments to make:	No response required.
MS	I would point out that extensive beds /reefs of Modiolus occur (at Noss Head) around 10 km miles to the north west of the proposed development area.	Information on Noss Head Modiolus reefs was sourced and included in the Annex 10A: Wind Farm Benthic Ecology Technical Report.
MS	What do they mean by "multivariate analysis such as dendrograms"? Dendrograms are an output from some analysis routine, similarity for instance. Which other software, other than PRIMER, was used?	Data analysis methods were clarified in Annex 10A: Wind Farm Benthic Ecology Technical Report.

Consultee	Summary of Consultation Response	Project Response
MS	Copepoda spp - are they benthic or pelagic species? If they are pelagic they may have been caught in the grab during deployment and so should not really be considered here.	Copepods were pelagic and were removed from data analysis.
MS	Are the mollusc biomass data for flesh only or do they include shell weights? This should be made clear in the text.	Data quoted was ash free dry weight which by definition excludes inorganic shell material.
MS	Comment - hence the need for grab sampling to ground truth video and still images	No response needed.
SNH	1. As per our email of 16 September 2010 (attached) SNH is satisfied that the trawl/sampling design for benthic survey is adequate. We assume that you also obtained comment from Marine Scotland (Science) in this regard.	Marine Scotland (Science) was consulted during the survey design.
SNH	2. In the report, the section showing results on fish states that 23 taxa were found. Only 10 are mentioned by name, and only 5 shown in the charts. We would recommend for the Environmental Statement that a technical appendix listing all recorded species would be useful. We would make the same comment with regard to the section on epibenthic invertebrates.	All raw data for grab and beam trawl surveys is provided in the appendices to Annex 10A: Wind Farm Benthic Ecology Technical Report.
SNH	3. As the survey was not seasonally replicated, interpretation of the data on mobile fish and mobile epibenthic invertebrates should take account of the likelihood that some such species will show seasonal patterns in presence and abundance.	This comment was noted and taken account of in the data interpretation within Annex 10A: Wind Farm Benthic Ecology Technical Report. Note that non mobile fauna can also be very seasonal in abundance. .
SNH	4. The report correctly acknowledges that beam trawls are not ideal for sampling of large demersal fish or pelagic fish. Indeed pelagic fish are unlikely to be captured at all. For large demersal fish the report states that the "data is consequently considered to be only qualitative for these fish" which we take to mean as confirming presence / absence. While this is true for some demersal fish species there are a number for which reference to other sources of information will be required to consider their possible presence / absence at the site.	These comments are appropriate to the natural fish and shellfish ecology assessment.

Consultee	Summary of Consultation Response	Project Response
SNH	5. We have noted the presence of biotope SS.SCS.ICS.Moe.Ven.Moerella, and we are currently checking whether or not this is to be classified as a PMF. (It may be that depth is a determining feature of the PMF as well as biotope-type. We are currently checking how the PMF description sheet should be interpreted.) I will get back to you with further advice in this regard, once I have a confirmed answer.	Despite follow up by email and phone calls, no further information was received and the assessment proceeded based on the worst case assumption that the biotope is indeed a potential PMF.

10.2.2 SCOPE OF ASSESSMENT

6. This assessment covers benthic ecology which, within the study area, is primarily infauna living within the sediments, although there are also small areas of hard substrate where epifauna dominate. Whilst the site characterisation survey undertaken to inform this assessment included the use of a 2 m scientific beam trawl which catch smaller demersal fish as well as epibenthic invertebrates, the natural fish communities and commercial fisheries (including sandeels, which spend much of their lives buried in the sand) are assessed in Section 11: Wind Farm Fish and Shellfish Ecology and Section 16: Wind Farm Commercial Fisheries respectively and are therefore not discussed in any detail in this Section. Section 16: Wind Farm Commercial Fisheries, also covers some commercially important invertebrates, notably scallops, but where relevant these are also mentioned here.

7. This Section considers physical effects, such as the direct effect of construction of the turbines and associated scour protection, and inter-array cables. It also considers noise created during construction, and possible effects of electromagnetic fields, as well as indirect and secondary effects such as those associated with changes to seabed sediments as a result of sediment deposition, or suspended sediments.

8. As well as the main offshore structures (turbines, foundations and substructures, meteorological masts and OSPs) this assessment includes the installation and operation of inter-array cables. The effects likely to result from the installation and operation of the OfTW are considered in Section 22: Offshore Transmission Works Benthic Ecology.

10.2.2.1 Geographical Scope

9. Published information for background was collected in respect of the whole Moray Firth area, although the majority relates to either the Smith Bank, or to areas much closer inshore or much farther offshore. Detailed information was collected from project specific surveys that were carried out during the autumn of 2010, primarily within the Wind Farm Site, but also extending to approximately 2 km beyond the site boundary in order to determine if the communities and habitats found extended beyond the Wind Farm Site. An unnamed sandbank in similar depths

some 13 km to the north east was also included as a possible reference area for any future monitoring programme. The area surveyed is defined as the Study Area for the purposes of this assessment.

10. A detailed technical report has been produced which describes the existing baseline environment of the Moray Firth and in particular the Smith Bank, drawing on both published information and the project specific site characterisation survey. The report is included in Annex 10A: Wind Farm Benthic Ecology Technical Report. This Section does not therefore repeat all of the information from the technical report but summarises the information that underpins the assessment.

10.2.3 BASELINE DATA COLLECTION

11. The existing baseline of the study area has been established through a review of available published information, field survey and laboratory analysis.

10.2.3.1 Survey Methods

12. The project specific survey involved single 0.1 m^2 Day grab samples at each of 84 sites (from 89 attempted) for infauna and sediment analysis; drop down camera survey at each of 61 sites using video and stills images; and 300 m long scientific beam trawls (2 m beam with chain mat and 4 mm cod end) at each of 14 sites to investigate smaller demersal fish and epibenthic invertebrates. Sample sites were selected following interpretation of detailed sidescan sonar survey of the Smith Bank carried out earlier in 2010. Areas thought more likely to consist of coarser, or variable, ground types were surveyed at a higher density than those thought to be on relatively uniform sandy areas. The scope and methods for the survey were agreed with Marine Scotland and other parties prior to the survey. The overall survey plan is shown in Figure 10.1 and Figure 10.2 and details of methods and results are given in the technical report in Annex 10A: Wind Farm Benthic Ecology Technical Report. The survey was carried out during October and November 2010.

13. Grab samples intended at Stations 4, 56, 81, 89, 103 were unsuccessful due to stones jamming the jaws of the grab, but camera images were obtained at all of these sites except for site 103. Separate samples were also taken at 12 of the grab sites for possible chemical analysis, from which six were ultimately selected (Stations 55, 70, 85, 92, 95 and 98) for laboratory analysis (Figure 10.1).

10.2.4 ASSESSMENT METHODOLOGY

14. The assessment has been carried out on several potential effects associated with both the construction activities, or the presence and/or operation of the Wind Farm once constructed (referred to as operational effects for simplicity). In deciding what potential effects should be assessed this assessment draws upon the experience of other wind farm developments across Europe and the UK, since there is now a considerable body of experience in this field, along with the consultations carried out with respect to the Wind Farm itself.

15. Potential effects associated with the construction of the Wind Farm that have been assessed are:

- Disturbance of the seabed;

- Increase in suspended sediments;
- Sediment deposition;
- Noise during construction; and
- Release of chemicals.

16. Potential effects associated with the presence and/or operation of the Wind Farm that have been assessed are:

- Loss of habitat;
- Scour effects;
- Changes to water movement;
- Creation of new habitat;
- Possible stepping stone effect for invasive species;
- Operational noise;
- EMF effects; and
- Changes in fishing activity.

10.2.4.1 Significance Criteria

17. The importance of relevant receptors (species and communities), as described above, is defined as low, medium or high, taking into consideration criteria such as extent, rarity, protected status and importance to the wider community (e.g. as an important food source, provider of habitat).

18. The magnitude of any potential effects is described then assessed as far as possible as negligible, small, medium or large, taking into account the known sensitivity of the receptor to the worst case effects that are expected. Sensitivities of the main receptors (biotopes and biotope complexes plus *Arctica islandica*) have been outlined in Section 10.3 in relation to the anticipated types of effects.

19. The significance level of the effect is then assessed using both of the above factors, i.e. importance of the receptor and the expected magnitude of the effect. The level of effects are assessed as negligible, minor, moderate or major significance following Table 4.3 presented in Section 4: EIA Process and Methodology, (except that where Table 4.3 refers to "sensitivity", the term "importance" is substituted here). As described in Section 4: EIA Process and Methodology, only effects at the level of moderate or major significance are considered significant in terms of EIA regulations.

20. These methods are considered as guidelines and on occasion it is necessary to exercise professional judgement where importance of receptors or magnitude of effect does not precisely fit the definitions provided.

10.2.5 WORST CASE SCENARIOS

21. The main direct effect of construction of the Wind Farm on the benthos is the loss of seabed habitats due to placement of the turbines foundations and OSP foundations. In this regard, the worst case scenario presented in the Rochdale Envelope for benthos is the use of gravity base foundations and their associated scour protection, since these are the largest foundations and hence result in the greatest area of existing seabed habitat permanently lost (though replaced by other habitats which

will colonise in time). The largest total area lost is associated with the gravity bases used with the 277 3.6 MW scenario, which also includes three gravity based OSPs. This is, therefore, the scenario that has been considered for the direct physical effects related to the loss of habitat as a result of construction of the structures, and the creation of new habitat.

22. For effects associated with construction and operation of inter-array cables the worst case scenario was less simple to define. Since laying concrete mattresses or rock placement will add to the amount of existing seabed habitat permanently lost the possibility of up to 50% of cable runs requiring such protection was taken into account in the assessment of loss of habitat. However, the installation and long term presence of cables can also cause sediment disturbance and changes to suspended sediment concentrations; in these regards Section 9: Wind Farm Physical Processes and Geomorphology has described the worst case scenarios and described and assessed the likely effects; the outputs of the physical processes assessments have been used here to assess the likely effects upon the benthic invertebrate communities or species. The relevant worst case scenario is trenching by energetic means (e.g. jetting) trenches with cross-sections of disturbance 2.5 m deep by 3 m wide in 'V' shaped profile, assuming (conservatively) that 100% of material would be re-suspended.

23. For other potential effects such as those associated with noise and EMF effects worst case scenarios are discussed in the relevant sections below.

24. For construction or operational effects related to physical processes (see Section 9: Wind Farm Physical Processes and Geomorphology), such as scouring, physical disturbance of the sediments by rigs and anchors, changes to suspended sediment levels, changes to water movement, and possible deposition of sediments onto the seabed, outputs from the physical processes assessment have been used in order to assess the likely effects upon the benthic invertebrate communities or species, and so the worst case scenarios are those identified within the physical processes assessments. Although the construction period may take up to five years, Section 9: Wind Farm Physical Processes and Geomorphology generally assumes a three year construction period. There is little to choose in terms of worst case effects on benthic fauna between three and five year construction periods, since the former would entail slightly more intensive effects but earlier overall recovery, whilst the latter would have slightly less intensive effects but a longer overall impact. For consistency, this Section follows Section 9: Wind Farm Physical Processes and Geomorphology in assuming a three year construction period.

25. Worst case scenarios that have been considered are described in more detail where necessary for each of the potential effects in the relevant sections below.

10.3 BASELINE CONDITIONS

10.3.1 PUBLISHED INFORMATION

26. According to the review of the SEA[1] Area 5 by Eleftheriou et al (2004), Smith Bank is a shallow bank (40 m water depth), with relatively coarse sediment, in comparison to much of the deeper offshore North Sea, which is composed of sand and shelly gravel, with occasional outcrops of rock. McIntyre (1958) noted that on the Smith Bank polychaetes and molluscs were the numerically dominant groups, but that the pea urchin *Echinocyamus pusillus* was the numerically dominant species, while the rather larger bivalve mollusc *Cochlodesma praetenue* contributed most of the biomass. Eleftheriou et al (2004) cite several studies which have suggested that northern North Sea benthic infauna and epifauna seems to be richer and more diverse than those in the central and southern North Sea, although this work is rather general and probably mostly relates to deeper areas than the Smith Bank. The same authors also point out that differing survey methods used in these studies make it difficult to be conclusive about this.

27. Of the few detailed studies that have been done in the area, the most comprehensive have probably been those carried out in support of the nearby Beatrice oil field developments. Notably, Hartley & Bishop (1986) reported on a large number of 1 mm sieved grab samples (mostly Day grab) from areas largely to the south of the Study Area carried out in 1977, 1980 and 1981. Most of their samples were therefore in deeper areas with finer sediments than encountered in the Study Area for the Wind Farm, but a few samples in the north east of their survey grid were in shallower areas on the Smith Bank, overlapping the southern part of the Study Area. These shallower areas had fine to medium sands with low mud content but variable gravel content, in contrast to the finer sediments in the deeper areas, and the presence of the bivalve *Tellina* (formerly *Moerella*) *pygmaea* was strongly associated with these shallower areas. Other fauna that were more abundant on the shallow Smith Bank area than elsewhere included the bivalve *Crenella decussata*, the polychaete worm *Travisia forbesii*, and the amphipods *Bathyporeia* spp. The polychaete *Spiophanes bombyx* and the bivalve *C. praetenue* were ubiquitous, being abundant in these shallower sands but also in the deeper, finer sands. Taxa mainly limited to deeper finer sediments, and hence at reduced densities on the Smith Bank samples, included numerous bivalves such as *Nucula tenuis*, *Dosinia lupinus*, *Gari fervensis*, *Abra prismatica* and *Tellina fabula,* the polychaetes *Goniada maculata* and *Pholoe minuta*, the amphipod *Urothoe elegans*, and the burrowing brittle star *Acrocnida brachiata*.

28. Hartley and Bishop (1986) considered the infauna of their study area to be rich and diverse, and noted that comparison with earlier reports suggested a degree of long term persistence of the fauna in qualitative and quantitative terms.

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[1] Strategic Environmental Assessment undertaken in support of the exploitation of offshore oil and gas resources.

29. The large bivalve *Arctica islandica* has been historically recorded in the Moray Firth. This species is long lived and slow growing and, though robust, thought to be susceptible to physical damage, for example by fishing gear. It is included in a draft list of PMFs by SNH due to its long lived nature, its susceptibility to fishing and other physical disturbance, and its declining status in UK waters. Although Hartley and Bishop (1986) do not specifically mention *Arctica islandica*, this species was found frequently during the surveys they discuss, along with subsequent Day grab surveys by the Oil Pollution Research Unit during the 1980s according to JNCC records as presented on, for example, the NBN Gateway website. Virtually all of these records, and all of the records with higher abundances[2], are from areas outside of the Study Area in the slightly deeper muddier sediments in the region of the Beatrice oil platform, roughly 2 to 16 km south west of the Wind Farm Site, with just a single record on the south end of the Smith Bank just within the survey area. Occasional further records on the Smith Bank area were reported by McIntyre in the 1950s (McIntyre, 1958).

30. No other potential benthic PMF species are reported from the area.

31. There is relatively detailed information on areas much closer inshore, notably in an SNH commissioned report on the Moray Firth SAC to the 30 m contour (Foster-Smith et al, 2009). Benthic communities in these areas are very varied and rather different to those in the Study Area. Foster–Smith et al (2009) considered many of the communities in the outer part of their study area to be variations on *Amphiura* (burrowing brittle stars) communities, which are associated with sediments with high mud contents. However, it is noteworthy that, as well as a variety of infaunal biotopes, they also report the presence of horse mussel (*Modiolus modiolus*) beds in the Inverness and Cromarty Firths. An estimated 4-5 km^2 of *Modiolus* beds/reefs are also known from depths of 40 m or so off Noss Head, in a band extending roughly from Wick northwards (Moore & Roberts, 2011). Whilst there are no reports suggesting the presence of beds or reefs of this species in the Smith Bank area, it was sensible to be aware of the possibility when planning the survey.

10.3.2 SURVEY RESULTS

10.3.2.1 Sediments

32. Sediment PSA, along with total organic carbon (TOC) content of the fine fraction (less than 63 µm), was carried out on small subsamples taken from the infaunal grabs. Distribution, especially of coarser sediments, was aided by interpretation of camera and sidescan data from geophysical survey work undertaken on behalf of BOWL. These results were used to aid interpretation of infaunal results, since the distribution and abundance of infaunal animals are heavily affected by sediment type. Sediment type is also discussed from the point of view of physical processes modelling in Section 9: Wind Farm Physical Processes and Geomorphology of this ES and for the likely suitability for sandeels in Section 11: Wind Farm Fish and Shellfish Ecology.

[2] JNCC records quote numerous grab samples with abundances in the range 6-12 but do not say what the units are.

33. Full results of the sediment particle size and TOC analysis are given in Annex 10A: Wind Farm Benthic Ecology Technical Report along with a more detailed discussion and analysis. The predominant sediment types according to BGS classification (Long, 2006) and the percentage contributions of mud sand and gravel are given in Figure 10.3 and Figure 10.4.

34. The majority of the seabed was dominated by medium sands, often with varying amounts of shell fragments, whole shell or gravel. Hard substrate seabeds such as cobble and boulders were very infrequent, though coarser material was found in scattered locations, mostly in a few small but discrete patches in the north west of the survey area, and towards the eastern boundary of the survey area, both within and outside the Wind Farm Site.

35. Substrata to the north of the survey area were predominantly composed of medium sand and slightly gravelly sand with a small cluster of stations to the north east of the area (Stations 12, 20 and 28) being composed of gravelly sand. Stations 1, 2, 3 and 20 just outside the north west edge of the Wind Farm Site and stations 102 and 104 on the small bank further to the north of the area (see Figure 10.3) were either slightly gravelly sand or gravelly sand. The deepest water depths were recorded within and just outside the north west of the Wind Farm Site on top of the Smith Bank.

36. The central western region of the survey area was predominantly medium sand. The central eastern region of the area was coarser than other parts with sandy gravel, gravelly sand and slightly gravelly sand being the predominant sediment type.

37. Sediments in the southern part of the survey area were broadly similar to those of the north with a mix of medium and coarse sand, slightly gravelly sand and gravelly sand. Water depths were shallowest in this area.

38. Percentage contribution data shows that the majority of grab stations sampled were predominantly sand with very little mud content overall (Figure 10.4). Finer sediments with some (though low) mud content were generally found in the northern part of the survey area with central and southern areas containing little or no mud content. Percentage contribution of gravel was greatest in the central eastern areas of the survey area.

39. In general, the overall coarseness of the seabed according to PSA was lower than had been expected from the acoustic survey information, and this was confirmed by camera observations. However, the results match well with published descriptions of the area including BGS Seabed Survey maps, and descriptions from past biological surveys as described earlier.

40. The TOC of sediments across the Study Area was mostly quite low, with a mean of 0.83% ranging from 0.24% at Station 92 in the southern portion of the survey area to 2.39% at station 22 on the north west edge of the Study Area.

41. In general, TOC was greatest in the rather finer and slightly muddier sediments within the northern areas and to some extent along the eastern edge of the survey

area where % gravel content was higher. Lowest TOC values were recorded in southern areas.

42. A smaller subset of additional sediment samples was also taken for analysis of a suite of potential metal and organic contaminants, due to the longstanding existence of hydrocarbon development activities on and around the Smith Bank. Organic contaminants (Polycyclic Aromatic Hydrocarbons (PAHs), n-alkanes, and total alkanes) were present at very low levels or not detected. No heavy metals were present at levels that exceeded Interim Sediment Quality Guidelines, CEFAS Action Levels or Marine Scotland Action Levels where these exist. There was no apparent relationship between distribution of any of the metals, including barium, and the distribution of known wellheads. Barium was present at levels ranging from 133 to 273 $mgkg^{-1}$, and whilst this may have come from past drilling activities, these levels are lower than published values for North Sea sediments sampled at greater than 5 km from oil and gas platforms, and do not suggest gross contamination. For more detail on contaminants analysis see Annex 10A: Wind Farm Benthic Ecology Technical Report.

10.3.2.2 Fauna

43. The biological communities were rich in terms of numbers of organisms and numbers of taxa; there were a total of 8,286 individuals from 356 taxa from the 84 grabs; mean values were 98.6 individual, 34.5 taxa and 2.88 Shannon Wiener diversity index, per 0.1 m^2 grab. The communities were not particularly rich in terms of biomass (mean of 2.98 gm^{-2} ash free dry weight). They were dominated numerically by a variety of worms and to a lesser extent molluscs that were largely as expected based on published reports, although the high abundances in some areas of the small fanworm *Jasmineira caudata* was not particularly expected for this area; however, this is a widespread and abundant species around the whole of the UK. Biomass was dominated by molluscs (41.8%), with polychaetes and echinoderms contributing most of the remainder.

44. Epifaunal communities, as identified by beam trawls and camera survey, were generally relatively sparse. Demersal fish communities were dominated by flatfish such as dab and plaice. Sandeels *Ammodytes tobianus* and *Hyperoplus lanceolatus* were also frequent in some of the beam trawls. On the limited areas of coarser seabed sediments modest numbers of organisms typical of such ground were recorded. Starfish *Asteria rubens*, urchins, especially *Echinus esculentus*, queen scallop *Aequipecten opercularis*, hermit crabs *Pagurus bernhardus* and *P. prideaux*, and spider crabs *Macropodia* spp, dominated the invertebrate community here, along with smaller numbers of a variety of other, mostly crustacean, species. Overall only two specimens of the great scallop *Pecten maximus* (known to be fished commercially in the area) and a single edible crab *Cancer pagurus* were caught, although beam trawls are not an ideal method for sampling these species. The queen scallops were less abundant on the finer sands in the north of the area than on the coarser sediments. Great scallops are known to occur on a variety of gravels and coarse to fine sands, even tolerating some silt or mud content (e.g. Mason,

1983), and hence can be expected to be widespread over the whole survey area, as observed in Section 16: Wind Farm Commercial Fisheries.

45. Community classification against the JNCC biotope classification was carried out, taking into account all of the trawl, grab, camera and sediment (including sidescan sonar) information, but influenced mostly by the infaunal grab sample data due to the strong predominance of sandy and gravelly sediments in the area. Four main biotopes (or variants of biotopes), or biotope complexes, were identified from the infaunal data, of which two are extensive within the survey area (SS.SCS.ICS.MoeVen *Moerella* spp. with venerid bivalves in infralittoral gravelly sand biotope and SS.SSA.CfiSa Circalittoral fine sand biotope complex) and two are patchy and/or limited in extent (a *Glycera lapidum* dominated version of the MoeVen biotope, and a variant of SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrinereis* spp. and venerid bivalves in circalittoral coarse sand or gravel with high abundances of the fanworm *Jasmineira caudata*). In addition a small patch of cobble and boulder reef dominated mostly by tubeworms and barnacles, and ascribed to the biotope SS.SCS.CCS.PomB *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles was identified in the north west of the area, totalling 0.021 km^2, and it seems likely that one or two smaller patches of less distinct (i.e. less easily detected on sidescan sonar) similar habitat occur elsewhere on the north western boundaries of the Wind Farm application site and towards the eastern boundary. This equates to potential Annex 1 habitat but of 'medium reefiness' at most according to the definitions provided in Limpenny et al (2010), with, in the main, a fairly sparse and not very diverse associated biological community, although larger boulders within the biotope had a slightly richer community including hydroids and soft corals *Alcyonium digitatum*.

46. A map of these biotopes and biotope complexes is given in Figure 10.5, and the summary descriptions and statistics (sediment and fauna richness and diversity) and the main features of each is given in Table 10.3. Estimates of the area of seabed covered by each biotope or biotope complex are provided in Table 10.4. Figure 10.5 also shows the area of the main records of high densities of the bivalve *Arctica islandica* relative to the Study Area.

47. No indications of potential biogenic Annex 1 habitats as defined under the European Habitats Directive, such as *Sabellaria spinulosa* reefs or *Modiolus modiolus* reefs were found. Despite the existence of *Modiolus* beds in shallow inshore parts of the Moray Firth, and to the north off Noss Head, only a single live example was found in the whole survey (in one of the beam trawl samples) and there were no accumulations of dead shell.

48. No important populations of nationally important, rare or otherwise unusual species were found during the survey. Although *Arctica islandica* (a PMF species according to SNH's draft PMF list) were found, there were only three individuals, all of which were juveniles, from a total of 84 infaunal grabs. This species is very long lived, with populations composed largely of individuals in the 40 to 80 years range having been reported in North Sea waters (OSPAR, undated) and is sensitive to physical damage such as by beam trawl (OSPAR, undated; Sabatini et al, 2008).

The adults can spend considerable time buried deep in the sediment, where they are probably too deep to be efficiently sampled by grabs. However, experimental evidence suggests that individuals spend no more than 30% of their time at depth, whilst the rest of the time the typical position is very close to the sediment surface (Taylor, 1976), and the periods spent at depth or at the surface are not synchronous within populations. Adult population densities of up to 16 m^{-2} have been reported in the Northern North Sea (OSPAR, undated), although mean densities over very wide areas are of course lower than this (Sabatini et al, 2008). Important adult populations can thus be expected to have been detected by the large number of grab samples used in this survey. Moreover, spending considerable time extremely close to the surface is known to render this species susceptible to damage from beam trawling, and thus it might be expected to be occasionally caught in beam trawls, but none were found in the trawls from this survey.

49. As described earlier, published records suggest that high densities are limited to areas outside of the Wind Farm Site approximately 2 to 16 km to the south west (as shown in Figure 10.5. It is therefore concluded that the Study Area does not constitute an important area for this species, and no species specific assessment of effects within the survey area is required. However, as potentially important populations may occur to the south west of the Wind Farm Site, the possible implications of changes to suspended sediment levels outside of the Wind Farm Site are assessed.

Table 10.3 Summary Descriptions and Statistics for Biotopes and Biotope Complexes Identified in the Benthic Survey Area.

50. The terms 'Group' and 'Stations' refers to the grab samples that were found to group together using multivariate statistics, and from which the summary statistics were prepared. The total number of taxa refers to combined data from the whole group of samples. All other values are means except for those in brackets which are ranges. Further details are provided in Annex 10A: Wind Farm Benthic Ecology Technical Report.

Biotope SS.SCS.ICS.MoeVen ***Moerella*** **spp. with venerid bivalves in infralittoral gravelly sand**					
Group 1a: Stations 9, 13, 29, 33, 37, 38, 41, 42, 44, 48, 51, 54, 55, 60, 62, 63, 65, 67, 70, 71, 72, 73, 79, 80, 84, 86, 87, 88, 91, 92, 93, 94, 96, 97, 98, 99, 100, 101. Stations 36 45 & 66 which clustered separately from this group were also ascribed to this biotope, but were not included in the calculated values below; see Annex 10A: Wind Farm Benthic Ecology Technical Report for details.					
Predominant sediment type:		Medium sands, but sometimes slightly gravelly or even gravelly			
% gravel (mean & range)	3.3 (0.2 - 26.5)	% sand (mean & range)	96.6 (73.5 – 99.7)	%mud	1.3 - 2.2
Total no of taxa	171	Countable ind $0.1m^{-2}$	55.1	Taxa $0.1m^{-2}$	25.1
S-W div index $0.1m^{-2}$	2.78	AFDW (gm^{-2})	2.95		
Most abundant taxa (to 0.45 $0.1m^{-2}$)				Colonial orgs (% occurrence) all	
Spiophanes bombyx	10.87	*Nemertea spp.*	0.61	*Lagotia viridis*	100%
Moerella pygmaea	6.29	*Poecilochaetus serpens*	0.61	*Athecata sp.*	8%
Ophelia borealis	4.58	*Bathyporeia*	0.61	*Hydrallmania falcata*	5%
Cochlodesma praetenue	3.21	*Guilliam soniana*		*Pedicellina sp.*	5%
Echinocyamus pusillus	2.32	*Travisia forbesi*	0.61	*Phialella quadrata*	3%
Copepoda spp.	1.58	*Abra prismatica*	0.58	*Sertularella gayi*	3%
Nephtys cirrosa	1.13	*Clymenura johnstoni*	0.53	*Sertularia cupressina*	3%
Glycera lapidum	1.11	*Aonides paucibranchiata*	0.47	*Obelia sp.*	3%

Biotope SS.SCS.ICS.MoeVen *Moerella* spp. with venerid bivalves in infralittoral gravelly sand					
Gari fervensis	1.05	*Phoronis spp.*	0.47	*Clytia hemisphaerica*	3%
Dosinia spp. juv.	1.05	*Pista cristata*	0.45	*Tubulipora sp.*	3%
Owenia fusiformis	0.89	*Dosinia lupinus*	0.45	*Disporella hispida*	3%
Edwardsia sp.	0.89	*Gastrosaccus spinifer*	0.45	*Beania mirabilis*	3%
Crenella decussate	0.87			*Escharella immersa*	3%
Euspira pulchella	0.76			*Escharella variolosa*	3%
Aponuphis bilineata	0.66			*Schizomavella sp.*	3%
This group is a good match for the biotope SS.SCS.ICS.MoeVen Moerella spp. with venerid bivalves in infralittoral gravelly sand. Many of the characteristic species, including *Tellina* (=Moerella) *pygmaea*, several worm species such as *Glycera lapidum* and *Spiophanes bombyx*, and some amphipod crustacea such as *Bathyporeia guilliamsoniana*, occur at quite high densities. Several venerid bivalve species, and other robust bivalves, are also found in these samples, notably *Dosinia lupinus* and *Dosinia spp* juveniles, with some *Timoclea ovata*, *Clausinella fasciata*, and *Goodallia triangularis* (not listed above as densities were lower so they were not amongst the most abundant taxa). As noted by Connor et al (2004) these often quite large species typically occur at comparatively low densities, and are hence often under-represented in grab sample; the densities found in these samples therefore may still be typical of the biotope. The sediment also matches well with the description in Connor et al (2004) of 'Medium to coarse sand and gravelly sand'. From the field notes it is clear that shell and shell fragments were often associated with these sediments, and may contribute much of the gravel sized particles, although not often sufficiently abundant to be noticed on the camera survey. There are few colonial or encrusting organisms due to the lack of hard substrate. However, the biotope on Smith Bank is deeper than is reportedly typical of this biotope, which is more usually limited to 20 m or less.					

Note: S-W div index = Shannon Wiener diversity index. AFDW = Ash free dry weight.

Biotope complex SS.SSA.CfiSa Circalittoral fine sand (it is not possible to determine which of the two constituent biotopes provides the better match)
Group 1b: Stations 1, 2, 3, 5, 6, 7, 8, 10, 11, 14, 18, 19, 20, 21, 22, 25, 26, 27, 34, 35, 49, 53, 68, 77, 78

Predominant sediment type:	Fine and medium sands, sometimes slightly gravelly

% gravel (mean & range)	1.6 (0.3 - 6.7)	% sand (mean & range)	97.8 (93 - 99.5)	%mud	0.1 - 2%
Total no of taxa	177	Countable ind. $0.1m^{-2}$	99.2	Taxa $0.1m^{-2}$	36.7
S-W div index $0.1\ m^{-2}$	2.86	AFDW(gm^{-2})	1.79		

Most abundant taxa (to 0.56 $0.1m^{-2}$)				Colonial orgs (% occ.) all	
Spiophanes bombyx	33.48	*Nephtys sp. juv.*	1.04	*Lagotia viridis*	92%
Cochlodesma praetenue	6.32	*Nephtys cirrosa*	0.96	*Phialella quadrata*	48%
Gari fervensis	5.00	*Crenella decussata*	0.96	*Athecata sp.*	40%
Abra prismatica	2.24	*Aricidea cerrutii*	0.96	*Bougainvillia sp.*	4%
Tellina fibula	2.08	*Edwardsia sp.*	0.84	*Hydrallmania falcata*	4%
Ophelia borealis	2.04	*Dosinia spp. juv.*	0.80	*Pedicellina cernua*	4%
Echinocyamus pusillus	1.92	*Diplocirrus glaucus*	0.80	*Alcyonidium mytili*	4%
Owenia fusiformis	1.80	*Timoclea ovata*	0.76		
Amphiura filiformis	1.68	*Bathyporeia elegans*	0.72		
Lumbrineris gracilis	1.60	*Glycera lapidum*	0.68		
Phaxas pellucidus	1.60	*Clymenura johnstoni*	0.68		

Biotope complex SS.SSA.CfiSa Circalittoral fine sand (it is not possible to determine which of the two constituent biotopes provides the better match)					
Poecilochaetus serpens	1.44	*Euspira pulchella*	0.60		
Copepoda spp.	1.32	*Lanice conchilega*	0.60		
Nemertea spp.	1.28	*Moerella pygmaea*	0.56		
Chaetozone christiei	1.20	*Spiophanes kroyeri*	0.56		
Scoloplos (scol.) armiger	1.16	*Spio decorata*	0.56		
Phoronis spp.	1.08	*Galathowenia oculata*	0.56		
This is a fairly rich and diverse community with few encrusting or colonial organisms due to the lack of hard substrate. The species present indicate the most likely biotope complex to be SS.SSA.CfiSa Circalittoral fine sand. This is split into two biotopes: SS.SSA.CfiSa.EpusOborApri *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand, and SS.SSA.CfiSa.ApriBatPo *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand, but neither of these biotopes is particularly well described due to an absence of reliable data, and the community found here appears to match quite well with both, due to fairly high numbers of both *Echinocyamus pusillus* and *Abra prismatica* along with modest numbers of the amphipod crustacean *Bathyporea elegans* and numerous polychaete species typical of clean fine sand such as *Spiophanes bombyx, Ophelia borealis* and *Nephtys cirrosa*. Despite the title of this biotope complex, the descriptions in Connor et al (2004) mention that the biotopes occur in medium to fine sands (from 25 to 100 m depth), matching very well with the sediments encountered here. They also consider that communities described by Basford and Elftheriou, 1988 and Kunitzer et al, 1992, for the central and northern North Sea belong to these biotopes, although they do not give any further information on distributions. It also has several characteristic species typical of two other biotopes: SS.SSa.IMuSa.FfabMag *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand, and SS.SCS.ICS.MoeVen Moerella spp. with venerid bivalves in infralittoral gravelly sand - for further details see Annex 10A: Wind Farm Benthic Ecology Technical Report.					

A variant of the biotope SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrinereis* spp. and venerid bivalves in circalittoral coarse sand or gravel that is unusually dominated numerically by the small fanworm *Jasmineira caudate*
Group 2: Stations 12, 23, 40, 57, 75, 76, 82, 85, 90

Predominant sediment type:	Gravelly sands & sandy gravels, sand elements dominated by coarse & medium sands

% gravel (mean & range)	23.7 (11.7 - 54.4)	% sand (mean & range)	69.7 (45.2 – 87.5)	%mud	<1
Total no of taxa	249	Countable ind. 0.1m^{-2}	334.3	Taxa 0.1m^{-2}	75.3
S-W div index 0.1m^{-2}	3.27	AFDW(gm^{-2})	8.09		

Most abundant taxa (to 1.56 0.1m^{-2})				Colonial orgs (% occ.) to 22%)	
Jasmineira caudate	61.33	*Thelepus cincinnatus*	2.89	*Lagotia viridis*	100%
Hydroides norvegica	49.00	*Atylus vedlomensis*	2.89	*Escharella immersa*	89%
Pomatoceros triqueter	26.67	*Mediomastus fragilis*	2.89	*Schizomavella sp.*	78%
Galathea intermedia	14.00	*Gibbula tumida*	2.78	*Porifera crusts indet.*	67%
Notomastus latericeus	12.67	*Polycirrus spp.*	2.56	*Disporella hispida*	67%
Glycera lapidum	8.33	*Spiophanes bombyx*	2.44	*Obelia sp.*	44%
Nemertea spp.	8.22	*Clymenura johnstoni*	2.33	*Alcyonium digitatum*	44%
Leptochiton asellus	7.33	*Lumbrineris gracilis*	2.11	*Tubulipora sp.*	44%
Phascolion strombus	6.00	*Malmgreniella mcintoshi*	2.11	*Escharella variolosa*	44%
Aonides paucibranchiata	5.33	*Nereimyra punctata*	2.11	*Microporella ciliata*	44%

A variant of the biotope SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrinereis* spp. and venerid bivalves in circalittoral coarse sand or gravel that is unusually dominated numerically by the small fanworm *Jasmineira caudate*					
Nematoda spp.	4.11	*Verruca stroemia*	2.00	*Sertularella gayi*	33%
Clausinella fasciata	4.11	*Polygordius spp.*	1.89	*Clytia hemisphaerica*	33%
Malmgreniella spp.	4.11	*Maera othonis*	1.78	*Hydrallmania falcata*	22%
Gari depressa	3.67	*Scalibregma inflatum*	1.67	*Pedicellina cernua*	22%
Spio armata	3.44	*Thracia villosiuscula*	1.67		
Echinocyamus pusillus	3.00	*Gnathia oxyuraea*	1.56		
Harmothoe spp.	3.00				

This very rich and diverse group (and with a high average biomass) is very difficult to match clearly with any biotope. The dominant species, the very small fanworm *Jasmineira caudata,* is only associated with two biotopes (SS.SBR.SMus.ModMx *Modiolus modiolus* beds on open coast circalittoral mixed sediment and SS.SMx.CMx.MysThyMx *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment) according to published comparative tables (JNCC comparative tables 0405). However, the community here is very clearly very different to both of these, with none of their main characterising features or species. This community is very rich in both infaunal and encrusting worms and best fits with the SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrinereis* spp. and venerid bivalves in circalittoral coarse sand or gravel biotope that has been noted previously in the central Moray Firth (JNCC, undated (b)) although the two characteristic species (*Mediomastus fragilis* and *Lumbrineris gracilis*) are both present in only modest numbers in these samples. The venerid bivalve *Clausinella fasciata* was abundant, whilst several other venerids (notably *Goodallia triangularis*, *Timoclea ovata* and venerid juveniles) were reported at reasonably high abundances. Other species found here that are characteristic of this biotope include numerous polychaete species and the small pea urchin *Echinocyamus pusillis*. The small squat lobster *Galathea intermedia,* usually indicative of very rough ground, was also very abundant. The larger stones present in some samples were colonised by encrusting organisms including the tubeworms *Hydroides norvegica* and *Pomatoceros triqueter*, several bryozoan and hydroid species, and the dead man's fingers *Alcyonium digitatum*.

A *Glycera* dominated version of the MoeVen biotope that is rather richer in species and individuals than typical MoeVen					
Group 3: Stations 43, 58, 74, 83, 95, 102, 104. Station 64 which clustered separately from this group was also ascribed to this biotope, but was not included in the calculated values below; see Annex 10A: Wind Farm Benthic Ecology Technical Report for details					
Predominant sediment type	Slightly gravelly sand or gravelly sand, (the sands being dominated by coarse & medium sands)				
% gravel (mean & range)	9.1 (1.7 - 21.2)	% sand (mean & range)	90.7 (77.9 – 90.7)	%mud	<1
Total no of taxa	122	Countable ind. 0.1m-2	78.5	Taxa 0.1m-2	37.5
S-W div index 0.1m-2	3.31	AFDW(gm-2)	2.54		

Most abundant taxa (to 0.88 0.1 m-2)				Colonial orgs (% occ.) all	
Glycera lapidum	6.13	*Phoronis spp.*	1.50	*Lagotia viridis*	75%
Notomastus latericeus	4.75	*Lanice conchilega*	1.50	*Disporella hispida*	25%
Aonides paucibranchiata	3.63	*Spio filicornis*	1.50	*Schizomavella sp.*	25%
Hydroides norvegica	3.25	*Aglaophamus rubella*	1.38	*Porifera crusts indet.*	12%
Ophelia borealis	3.00	*Polygordius spp.*	1.25	*Sertularella gayi*	12%
Nemertea spp.	2.75	*Poecilochaetus serpens*	1.13	*Pedicellina sp.*	12%
Pista cristata	2.25	*Phascolion strombus*	1.13	*Tubulipora sp.*	12%
Spiophanes bombyx	2.13	*Euspira pulchella*	1.13	*Alcyonidium sp.*	12%
Pisione remota	2.13	*Hesionura elongata*	1.13	*Alcyonidium diaphanum*	12%
Moerella pygmaea	2.00	*Edwardsia sp.*	1.00	*Escharella immersa*	12%
Syllis armillaris	2.00	*Clymenura johnstoni*	1.00	*Escharella variolosa*	12%
Urothoe marina	2.00	*Spio armata*	1.00		

A *Glycera* dominated version of the MoeVen biotope that is rather richer in species and individuals than typical MoeVen					
Aricidea cerrutii	1.75	*Hyperoplus lanceolatus*	1.00		
Jasmineira caudate	1.63	*Atylus vedlomensis*	0.88		
Echinocyamus pusillus	1.63	*Pontocrates arenarius*	0.88		
Syllis cornuta	1.63				

This moderately rich and very diverse group (although with a very low average biomass) is very strongly dominated by polychaete worms (this being the reason for the relatively low biomass, worms being often far smaller than many molluscs and echinoderms, for example), but less gravelly and less rich than groups 1a, 1b and 2. Many of the species present, including the top three species, as well as *Ophelia borealis*, *Echinocyamus pusillus* and several venerid bivalves, are typical of the **MoeVen** biotope. However, the top three species (all polychaetes) are not usually this abundant in this biotope, whilst *Tellina (=Moerella) pygmaea* itself is present at a modest average of 2 individuals per $0.1m^2$. The sediment in these samples is typical of MoeVen.

This group of samples occurs in a relatively narrow band along parts of the eastern edge of the survey area, but also includes the two samples taken at the reference station on a sandbank to the north east (Stations 102 and 104).

Glycera lapidum is the characteristic and dominant species in a much more impoverished biotope, SS.SCS.ICS.Glap *Glycera lapidum* in impoverished infralittoral mobile gravel and sand, which also typically includes *Spiophanes bombyx* and *Ophelia borealis*, but with few other taxa. Connor et al (2004) note that this biotope may well be an impoverished version of the MoeVen biotope that develops when there is increased sediment disturbance. Like the MoeVen biotope, the Glap biotope is considered by Connor et al to occur more typically in shallower water, to a maximum of 20 m.

Oddly, however, this community, although strongly dominated by *Glycera lapidum* is rather richer and more diverse (see indices above) than the more typical MoeVen community described earlier (group 1a).

Table 10.4 Summary of the Area Covered by Each of the Main Biotopes or Biotope Complexes Found in the Study Area

Biotope complex / biotope (or variant)	Total area (km²)	Area outside Wind Farm application site boundary (km²)	Area within Wind Farm application site boundary (km²)
a) SS.SSA.CfiSa Circalittoral fine sand biotope complex	83.32	40.95	42.37
b) SS.SCS.ICS.MoeVen biotope	86.07	11.32	74.74
c) SS.SCS.ICS.MoeVen biotope(*Glycera* dominated variant)	7.25	0.50	6.75
b) + c) (=all MoeVen biotope)	93.31	11.82	81.49
d) S.SCS.CCS.MedLumVen biotope (*Jasmineira* dominated variant)	9.68	2.14	7.54
e) SS.SCS.CCS.PomB biotope	0.021	0	0.021

10.3.3 BENTHIC HABITATS AND COMMUNITIES ALONG THE OFFSHORE TRANSMISSION WORKS

51. The construction of the OfTW is subject to a separate assessment (see Section 22: Offshore Transmission Works Benthic Ecology); however, it is also helpful here to understand the nature of the communities found in order to assess possible indirect effects of the Wind Farm. A project specific benthic survey was carried out in June 2011 using primarily camera observations, supported by grab samples that were analysed for particle size distribution and some potential contaminants; for details see Section 22: Offshore Transmission Works Benthic Ecology.

52. The northern half of the OfTW corridor was dominated by fine sands, typically with around 5 to 8% of mud content. Virtually no fauna were observed in these areas during the OfTW survey, which primarily used camera survey supplemented by 17 sediment samples. However, the deep area of muddy sediments in central parts of the corridor had a high density of burrows of a variety of sizes, suggesting the likely presence of burrowing megafauna such as the crustaceans *Nephrops norvegica* (scampi) or *Callianassa* sp (burrowing mud shrimp). Several sea pens *Pennatula phosphorea* were seen, albeit at a low overall density, and the area was tentatively ascribed to the biotope S. SMu.CFiMu.SpnMeg seapens and burrowing megafauna in circalittoral mud, but with a low density of sea pens. This biotope is listed on the draft list of PMFs provided by SNH and is thus regarded here as an important biotope. Towards the inshore end of the OfTW corridor fine sand again dominated, whilst close inshore there were numerous areas of cobbles with communities dominated by encrusting tubeworms and barnacles, along with coralline and other red algae.

10.3.4 MORAY FIRTH ROUND 3 ZONE BENTHIC HABITATS AND COMMUNITIES

53. Surveys in relation to the eastern part of the Moray Firth Round 3 Zone development have been carried out separately by EMU Ltd using similar methods to those employed for the Wind Farm survey, i.e. a suite of camera, grab and 2 m beam trawl surveys, and involved reference sites for grab samples on the same sandbank to the north east of the Wind Farm Site. Liaison during the interpretation of both sets of survey results allowed for the production of a single biotope map that showed a good degree of agreement. This biotope map is shown in Figure 10.6. Occasional small areas of PomB biotopes that are too small to appear on the map occur in both areas.

54. Communities within the eastern part of the Moray Firth Round 3 Zone site are very similar to those found in the Wind Farm Site. Both areas are dominated by a mixture of fine sand communities and coarser sand and gravel communities.

55. Within the Moray Firth Round 3 Zone the fine sand areas were a good match for the biotope SS.SSA.CfiSa.EpusOborApri *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand, except in the deeper, slightly muddier south eastern area where it also contained some elements of an inshore community characterised by the bivalve *Tellina* (formerly *Fabulina*) *fabula* and the polychaete worm *Magelona* spp. In the Study Area the fine sand communities matched equally well to the two main circalittoral fine sand communities that have been described. All of these communities are very similar, considered to be of low importance, and sensitivities are as described for the CaFisa biotope earlier.

56. The MoeVen biotopes that are found in the Wind Farm survey were not found in the Moray Firth Round 3 Zone survey samples. The Wind Farm survey found that the differences between the MoeVen communities and the offshore fine sand communities were relatively subtle; the two share many of the same species, with the abundance of the characterising bivalve *Tellina pygmaea* being the main distinguishing feature. The MoeVen communities were on slightly coarser sands with generally higher gravel contents. However, in contrast to the Wind Farm survey, where the characteristic bivalve *Tellina (Moerella) pygmaea* was highly abundant in many samples, the same species was hardly found at all in any of the Moray Firth Round 3 Zone survey samples. It is likely that in reality there is a gradual transition between the MoeVen and fine sand communities that lies approximately in the region of the boundary between the two developments.

57. Communities associated with more gravelly seabeds were found in both areas but especially in the Moray Firth Round 3 Zone. In the Study Area and parts of the Moray Firth Round 3 Zone these could be confidently ascribed to the biotope SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrinereis* spp. and venerid bivalves in circalittoral coarse sand or gravel, whereas in many parts of the Moray Firth Round 3 Zone the community was less of a match to that biotope and was therefore simply described to biotope complex level (SS.SCS.CCS Circalittoral Coarse Sediment). Connor et al (2004) consider that the MoeVen biotope is a shallow water version of the MedLumVen biotope. The importance and

sensitivities of the MedLumVen biotope as described below are applicable to all of these areas.

58. In both survey areas there are also very occasional small areas of cobble that are dominated by scour tolerant tubeworms and barnacles. These areas match the biotope SS.SCS.CCS.PomB *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles, although in places larger more stable boulders within the community bear a slightly richer community than is typical of this biotope.

59. The bivalve *Arctica islandica* (a draft PMF species) was found in low numbers in the Moray Firth Round 3 Zone, and all were juveniles.

60. The Moray Firth Round 3 Zone survey found a very similar range of larger epifauna to the Wind Farm survey. In both surveys the queen scallop *Aequipecten opercularis* was found far more frequently than the great scallop *Pecten maximus*, (the latter was actually absent from the Moray Firth Round 3 Zone survey) whilst other commercial invertebrates such as prawns, shrimps, edible crabs and whelks were at very low abundance.

61. Communities in the western part of the Moray Firth Round 3 Zone, which is anticipated to be less developed than the eastern part, have not yet been described in detail, but are likely from existing knowledge to contain some areas of finer sediments with fauna similar to that described earlier for the Beatrice oil field, including numerous bivalves such as *Cochlodesma praetenue*, *Nucula tenuis*, *Dosinia lupinus*, *Gari fervensis*, *Abra prismatica* and *Tellina fabula*, the polychaetes *Spiophanes bombyx*, *Goniada maculata* and *Pholoe minuta*, the amphipod *Urothoe elegans*, and the burrowing brittle star *Acrocnida brachiata*.

10.3.5 IMPORTANCE AND SENSITIVITY OF COMMUNITIES AND SPECIES

62. This Section summarises for each of the main benthic receptors, their level of importance, along with known sensitivities to the types of possible changes thought most likely to be relevant (particularly disturbance/physical effects and changes to water movement and sediment regimes). For issues likely to be less important to invertebrates but still worthy of discussion, such as noise or EMF, the sensitivity is briefly discussed in the relevant section.

63. No important communities of nationally scarce, nationally rare or protected species were found during the surveys. The following assessments have therefore been largely carried out at the level of the biotopes/communities occurring in and around the Wind Farm Site, with the exception of *Arctica islandica* which has historically been found to the south west of the Wind Farm Site. Effects on natural fish communities and on commercially important shellfish and fish have been assessed in Section 11: Wind Farm Fish and Shellfish Ecology and Section 16: Wind Farm Commercial Fisheries respectively.

64. Taking into consideration the extent, rarity, importance in the food web, and ability to create, modify or improve habitats, the importance of the biotope / community is determined to be at one of three geographical levels: the Wind Farm Site (low

importance); the Moray Firth (medium importance) and northern North Sea waters or wider UK (high importance) to allow determination of the significance of any effects.

65. Sensitivity to some of the more important kinds of environmental changes which might be envisaged as a result of the development of the proposed Wind Farm is then summarised. Sensitivity of organisms or biotopes is generally considered to be a function of both its intolerance to the effect, and its ability to recover afterwards (assuming suitable conditions) as described by the Marine Life Information Network (MarLin, undated). Relevant benchmarks used by MarLin in assessing sensitivity to particular effects include the following.

- Physical effects and abrasion - force equivalent to a standard scallop dredge landing on or being dragged across the organism (a single event is assumed);
- Sediment deposition (smothering) - all of the population of a species or an area of a biotope is smothered by sediment to a depth of 5 cm above the substratum for one month; and
- Increase in suspended sediments - an arbitrary short term, acute change in background suspended sediment concentration, e.g. a change of 100 mg l^{-1} for one month.

10.3.5.1 Biotope SS.SCS.ICS.MoeVen Moerella spp. with venerid bivalves in infralittoral gravelly sand (including the Glycera dominated version of the biotope)

66. The *Glycera* dominated version of the biotope is included here because it is substantially the same as the MoeVen biotope but with the addition of a high density of the worm *Glycera lapidum*. This worm is typical of very disturbed habitats, with a strong ability to colonise disturbed sandy or gravelly areas. The MoeVen biotope occupies most of the central and southern parts of the Study Area. The MoeVen biotope is on a draft list of 53 species and habitats that are considered by SNH as PMFs. According to the SNH website PMFs are habitats and species which we consider to be of greatest marine nature conservation importance in Scottish territorial waters. The draft PMF list contains 53 habitats and species and will be used to guide future research and support the advice SNH gives on marine biodiversity.

67. According to SNH (M Carruthers pers comm 7 March 2011) this biotope qualified as a PMF based on the following criteria.

- Proportional importance: Scottish territorial waters are considered to be nationally important, based on the known distribution of records.
- Decline/ threat of decline: considered to be in decline and/or under threat of decline as a result of anthropogenic pressures.
- Functional importance: this habitat is considered to be of functional importance through supporting important food species.

68. According to Durkin (2008) this biotope is probably an important source of food for opportunistic predatory fish such as gurnards, dragonets and whiting, and benthic

scavengers such as whelks; all of these except whiting were found in the site specific survey, and whiting can be expected to occur there too.

69. However, SNH (C Gall, pers comm 30 August 2011) were recently considering whether the depth at which the MoeVen biotope occurs should be a factor in determining its value and hence whether it should be considered as a PMF in all cases or only when it occurs in shallow waters. Since the Wind Farm Site is much deeper than the areas in which this biotope normally occurs, this could conceivably reduce its perceived importance in this area in the future.

70. *Tellina pygmaea (*formerly known as *Moerella pygmaea),* the most important characteristic species of the biotope, has long been known to be abundant in the Smith Bank area. However, the list of known areas in Scottish waters from where this biotope has been recorded does not presently appear to include the Moray Firth with the majority of records from Shetland, Orkney and some instances on the west coast of Scotland (e.g. Loch Slapin and Loch Kishorn) and Outer Hebrides (e.g. Sounds of Barra and Harris) (SNH; M Carruthers pers comm 7 March 2011). This survey therefore appears to represent a considerable increase in known area of this biotope in Scottish waters, although this cannot be quantified on present information. The MoeVen biotope was also present to an unknown extent on the sandbank to the north east of the survey area. The distribution in the rest of the UK is similarly poorly known, although it is reported that there are areas of this biotope off the North Wales coast (CMACS, 2005) that are not reported by, for example, the JNCC website (JNCC, undated (a)). JNCC records do not suggest any strong Scottish bias for this biotope, but do suggest that it may be more prevalent on western coasts than eastern coasts of the British Isles.

71. No published information has been found regarding the apparent decline or threat of decline of this biotope.

72. Whilst it is clear that this biotope can be moderately rich in numbers of individual organisms and numbers of taxa, it is in fact less so in both respects than the rest of the survey area. Both the circalittoral fine sand biotope complex and the MedLumVen biotope have higher mean values for numbers of taxa, individuals and biomass. However, it is likely that the MoeVen biotope contains a range of reasonably abundant potential prey species, particularly bivalves such as *T. pygmaea*, *Cochlodesma praetenue*, and *Gari fervensis*, that may represent suitable prey species for a range of predators including demersal fish. This biotope is likely to provide areas of habitat ideal for sandeels, but sandeels are assessed separately in Section 11: Wind Farm Fish and Shellfish Ecology. Neither this, nor other biotopes, in the Smith Bank area, are considered to be of importance for bird feeding (see Section 13: Wind Farm Ornithology).

73. Due to its possible relatively high abundance in Scottish waters, the possibility that it is either in decline or under threat of decline, its likely functional importance as a food resource, and the fact that, as a result of these three factors, it is listed by SNH as a possible PMF, this biotope is considered here to be of high importance.

74. Sensitivity to physical effects of this biotope is likely to be low since the fauna are predominantly infauna, and are at least to some degree mobile. According to the MarLin website (Durkin, 2008) the sensitivity to physical abrasion or displacement is low, based on an intermediate intolerance to the effect (i.e. some effect can be expected) and a high recoverability. Sensitivity to deposition of sediments is considered to be very low. A very minor component of the fauna is sessile epifauna that would not be expected to survive long term burial beneath large amounts of sediments should this occur as a result of installation or operational activities, but overall sensitivity of the community would nevertheless be expected to be low. Finally, overall sensitivity to raised levels of suspended sediments is considered to be very low for this biotope. However, it is recognised that very large scale changes that could substantially change the nature of the sediments in the long term (such as major changes to particle size composition) could substantially change the nature of the community.

75. These conclusions are supported by several studies that have concluded that sandy sediment communities are able to recover rapidly from strong physical effects such as fishing with beam trawls or aggregate extraction (Kaiser and Spencer, 1996; Newell et al, 1998; Robinson et al, 2005). Very mobile sandy communities may recover in a matter of months to a year – full recovery of the MoeVen community from most effects can be expected after six months according to Durkin (2008). Complete recovery from major effects can be expected to take somewhat longer than this, however, given that some of the characteristic members of the community are venerid bivalves that may live for several years or more and may not reach full size for several years.

10.3.5.2 Biotope Complex SS.SSA.CfiSa Circalittoral fine sand

76. This biotope complex is mainly described from central and northern North Sea areas (Connor et al, 2004), but its apparent absence from more southern and western parts of Britain may be simply due to a lack of information. It is widespread in the north of the Study Area, and seems to show strong similarities to both the MoeVen biotope (but with far fewer *Tellina pygmaea*) and to the inshore FfabMag biotope, and again has a range of reasonably abundant potential prey species, particularly bivalves such as *Cochlodesma praetenue*, *Gari fervensis*, *Abra prismatica* and *Tellina fabula* that may represent suitable prey species for a range of predators including demersal fish. This biotope complex is widespread on the adjacent, slightly deeper, Moray Firth Round 3 Zone survey area to the east (unpublished information from Moray Firth Round 3 Zone). Due to its possible higher abundance in Scottish waters, and likely functional importance to some degree as a source of food items for larger benthic organisms including demersal fish, this biotope is considered to be of medium importance.

77. There is little or no published information on likely sensitivity of this biotope to potential effects, but it is somewhat similar to the MoeVen biotope, sharing many of the same species, and with an even more dominant infaunal component. Thus the sensitivity to physical abrasion or displacement is again likely to be low, sensitivity to deposition of sediments is likely to be very low, and sensitivity to raised levels of

suspended sediments low. Recoverability from all but the most major effects is also likely to take place over a relatively short time scale of months.

10.3.5.3 Biotope SS.SCS.CCS.MedLumVen Mediomastus fragilis, Lumbrineris spp. and venerid bivalves in circalittoral coarse sand or gravel (Jasmineira dominated).

78. This is a rich and diverse biotope, with 249 taxa recorded during this survey, and with much higher levels of biomass than the other infaunal biotopes recorded. Although unusual for this biotope in being dominated by large numbers of the very small fanworm *J. caudata*, this is not considered to influence the nature or importance of the biotope. The biotope appears to be patchy in and around the Wind Farm application site. Along with the less clearly defined circalittoral coarse sand habitat (the SS.SCS.CCS circalittoral coarse sand biotope complex, in which MedLumVen is one of the representative biotopes), it also occurs within the adjacent Moray Firth Round 3 Zone, although there it is not heavily dominated by *J. caudata*) (unpublished information from Moray Firth Round 3 Zone). It seems to be a widespread biotope around the east and west coasts of the British Isles (e.g. Durkin, 2008; LAL, 2005; and JNCC, undated (b)) especially in the Irish Sea. It contains a wide variety of organisms many of which may be important prey items for demersal fish, including polychaete worms, bivalves and crustacea. Thus, because of both its richness and diversity, and also its likely importance as a food resource, the MedLumVen biotope is considered to be of importance at the level of the Moray Firth and is therefore considered to be of medium importance.

79. The coarser sediments supporting the relatively rich and diverse MedLumVen biotope are probably considerably less mobile than those of the predominant sandy sediments of the MoeVen biotopes and the fine sand biotope complex, nevertheless many of the dominant taxa are polychaete worms, such as encrusting tubeworms *Hydroides norvegica* and *Pomatoceros triqueter*, and the fee living *Glycera lapidum*, that have a strong tolerance to disturbance. The less abundant (but characteristic of the biotope) venerid bivalves are also known for being very robust, with thick, strong shells. There are many other encrusting species tolerant of mobile gravels, including barnacles, especially *Verruca stroemia*, and bryozoans such as *Schizomavella* sp, *Escharella* spp. Nevertheless, this biotope clearly occurs on slightly less disturbed areas than the biotopes mentioned above, and some epifauna such as dead man's fingers (*A. digitatum*) are probably less robust and slightly less tolerant of increased suspended sediment than those mentioned above. The tolerance to physical effects of the tiny fanworm *J. caudata* that dominates these areas numerically is unclear, but this species typically has a maximum length of 5 mm and is likely to have a rapid regeneration time.

80. It is generally reported that more stable gravelly sediment communities take longer than more mobile sandy sediment communities to recover fully from severe physical effects such as those associated with aggregate extraction or repeated beam trawling, with the most stable examples requiring ten years or more. More mobile gravel communities within the MedLumVen biotope are likely to recover somewhat more rapidly than this, although probably slightly more slowly than the MoeVen and fine sand communities.

81. The Marlin website (Rayment, 2008) considers that this biotope has an intermediate tolerance to physical abrasion and disturbance but a high recoverability, resulting in an overall low sensitivity to these effects, whilst sensitivity to deposition of sediments and to raised levels of suspended sediments are both considered to be very low.

10.3.5.4 Biotope SS.SCS.CCS.PomB Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles

82. This epifaunal biotope, although perhaps slightly richer in this area than typical examples of the biotope, is very limited in extent within the survey area, although small patches are also known from the adjacent Moray Firth Round 3 Zone survey area (EMU; P. English pers comm May 2011). It is dominated by robust tubeworms and barnacles that are tolerant of high degrees of scour, and is unlikely to form a particularly important food resource. Whilst this biotope is potentially an Annex 1 reef feature, it has been determined within the Study Area to be of 'medium reefiness' at most according to the scale of Limpenny et al (2010), and is of low diversity, as well of limited extent. It is therefore considered to be of importance at the level of the Wind Farm site and is therefore defined as being of low importance.

83. The main characteristic fauna of this biotope are physically robust, being tolerant to a high degree of scour. The biotope is also unlikely to be particularly sensitive to raised levels of sediments, since the biotope is frequently found in areas of high water movement adjacent to sandy areas, such as the Wind Farm site. During the site characterisation survey carried out in autumn 2010 high levels of turbidity were seen during the camera survey in all the coarser areas, including on this biotope, with high levels of silt being disturbed from the seabed by the survey camera. The biotope would be sensitive to burial beneath several centimetres of sediment for long periods however, since the most abundant noted fauna are not mobile.

10.3.5.5 Arctica islandica

84. This large bivalve species is very long lived, with populations composed largely of individuals in the 40 to 80 years range having been reported in North Sea waters (OSPAR undated). It is sensitive to physical damage such as by beam trawl (OSPAR undated; Sabatini et al, 2008). SNH has included this species on their draft list of PMFs due to its long lived nature, its susceptibility to fishing and other physical disturbance, and its declining status in UK waters. This species is therefore considered here to be of high importance.

85. This species is robust, with a strong, thick shell. However, as a long–lived species that spends much of its time very close to the sediment surface (often sufficiently close for part of the shell or siphon to be visible) it is vulnerable to physical effects, notably from bottom fishing gear such as beam trawls and scallop dredges (e.g. OSPAR undated). Single encounters are not always fatal, but being so long lived multiple encounters are likely for this species, and a widespread decline in North Sea waters is considered to be the result of long term damage caused mainly by beam trawling, although aggregate extraction is considered to be also a threat. Sabatini et al (2008) consider this species to have an intermediate intolerance to

physical effects and only a moderate ability to recover (up to ten years), while sources quoted by OSPAR suggest mortalities of 74% to 90% for adults actually caught in a beam trawl. Despite spending most of its time at the sediment surface, this species does undertake considerable vertical movements within approximately the top ten cm of the sediment, and is considered by Sabatini et al (2008) to have an intermediate tolerance of smothering events, with full recovery requiring up to ten years, and to be tolerant of raised levels of suspended sediments.

10.4 ASSESSMENT OF POTENTIAL EFFECTS

10.4.1 CONSTRUCTION EFFECTS

10.4.1.1 Disturbance of the Seabed

86. Disturbance of the seabed will occur during placement of the turbines, OSPs, meteorological masts and associated supports and scour protection, and during the laying of the inter-array cables and associated scour protection.

87. The anticipated disturbance is likely to arise in three main ways each of which is discussed below. These are:

- A 'temporary zone of influence' that has been identified in the Rochdale Envelope (see Section 7: Project Description) as an area of disturbance at each of the installations that extends beyond the permanent zone of influence;
- Depressions in the seabed caused by jack-up rig legs and large anchors associated with installation activities; and
- Ploughing, trenching or jetting activities associated with the laying of inter-array cables.

88. The scenario that gives the largest estimated areas of disturbance is that of 277 turbines supported on gravity bases, gravity bases to the three OSPs, and with an associated 350 km of inter-array cables.

89. The disturbed area of seabed for each structure as identified in the Rochdale Envelope has been estimated by subtracting the area of permanent influence from the total area of the temporary zone of influence, and the total area involved for the worst case scenario can thus be estimated as 0.562 km^2, or 0.428% of the seabed in the Wind Farm Site. This is assumed mainly to involve disturbance associated with activities such as the seabed preparation that is required for gravity bases in particular, and ancillary disturbance during dumping of rocks or other scour protection.

90. Jack-up rigs will be used for placement of gravity bases and other parts of the structures, piling activities, and scour protection. There are typically four to six legs on each rig, and these will each create temporary depressions in the seabed that have been described and assessed in Section 9: Wind Farm Physical Processes and Geomorphology. The pits are each expected to be up to 30 m^2 in area, conical in shape and up to 1.9 m deep at the centres, to be composed of largely the same material as was previously present, and to fill in naturally over a period of six months to four years.

91. The precise number of jack-up rig deployments is unknown, but the likely scenario is that no more than two rig deployments will be required for placement and erection of each turbine and OSP structure, and assuming six legs per rig; this would equate to a total disturbed area of 360 m^2 per structure, or a total of less than 0.101 km^2 (approximately 0.078%) over the whole Wind Farm Site. The deployments would be spread over the anticipated construction period of three years, which means that some scour pits are likely to have fully recovered (in terms of both sediment and biota) before others have been created.

92. Anchor dredge marks have also been described in Section 9: Wind Farm Physical Processes and Geomorphology. Pits caused by anchors are anticipated to be far smaller than those caused by jack-up legs and expected to fill in over shorter periods of a few months to a few years, although there will in some case be additional small scale disturbance caused by the anchor dragging before it bites. The number of deployments required is not known but it is assumed here to be broadly similar to number of jack-up rig leg deployments, resulting in an affected area far smaller than that of the jack-up legs, assumed here to be half, and lasting for shorter periods.

93. The majority of the organisms within each jack-up leg pit is assumed to be killed, whereas with anchor marks this is very unlikely; the majority of animals will simply be displaced, although some infauna may end up exposed at the surface, or buried more deeply than previously, while some epifauna (which are not abundant in the Wind Farm Site) may end up being buried.

94. Exposed animals may or may not be able to rebury before being predated upon. They may also be relocated by water movements but given the relatively uniform nature of the sediments the majority would be expected to be deposited in areas that are still suitable habitat for them. A proportion of buried animals will survive if they are mobile species (as most are in the majority of the area). Time taken for pits created by jack-up legs to recover from disturbance can be expected to be towards the upper end of the ranges quoted in Section 9: Wind Farm Physical Processes and Geomorphology, whereas the anchor marks may be more variable, and associated recovery times are likely to be more rapid.

95. In relation to the activities associated with the laying of the inter-array cables the disturbed area worst case consists of a trench up to 3 m across following jetting/trenching over the whole 325 km of the potentially buried cable route (additional adjacent areas will be subject to deposition of sediments suspended during the installation but this is assessed separately below). This equates to a disturbed area of 0.975 km^2 or 0.74% of the Wind Farm Site. While some, mostly epifaunal, organisms are expected to be killed by the passage of the plough, jet or trenching machinery, the majority will be displaced, of which some, particularly the more mobile fauna, are likely to survive. It should be noted that 50% of this area is already assessed as having been permanently lost beneath stone or concrete mattresses.

96. Affected areas are likely to have a variable degree of reduction in faunal richness and diversity. Faunal communities are likely to recover over periods broadly

similar to those quoted for filling in of the pits or trenches, i.e. a few months to possibly up to approximately four years, although due to the sandy nature of most of the area, recovery is expected to be towards the lower end of this range in most cases. Recovery of the faunal communities will start immediately by migration of animals from adjacent areas (Royal Haskoning and Bomel Ltd, 2008), new settlement of larvae, and some regrowth of damaged colonial organisms such as hydroids, bryozoans, sponges and dead man's fingers. Commencement of recovery of the faunal communities will not be dependent upon the complete filling in of any pits or trenches but will proceed in tandem with that process, and some will have recovered completely before others have been created.

Assessment

97. The PomB biotope is expected to be particularly tolerant of many of these disturbances, and the MedLumVen biotope to be the least tolerant as described in the section above on sensitivities, but even this latter biotope can be expected to recover fully over periods of a few years. The MoeVen community, which is considered to be of high importance, has a high ability to recover from such effects. Thus, for all of the benthic communities present, seabed disturbance is considered to be an effect of very small magnitude. For the MoeVen community, which is considered to be of high importance but has a high ability to recover from such effects, this results in a negative effect of minor significance; for the MedLumVen biotope (medium importance) a negative effect of minor significance, and for the PomB biotope and circalittoral fine sand biotope complex (low importance) a negative effect that is of negligible significance. The effect is therefore not significant in terms of the EIA Regulations.

10.4.1.2 Increase in Suspended Sediments

98. A local increase in suspended sediments levels in the water column is expected in the areas where construction activity occurs, with the potential for sediment plumes to also influence more distant areas. Such increases were modelled and assessed in Section 9: Wind Farm Physical Processes and Geomorphology in respect of activities including seabed preparation for foundation installation, drilling if required to aid pile installation, and inter-array cable installation. The anticipated worst case increase in suspended sediment concentrations close to the seabed, where levels tend to be highest, and where they have the most potential to affect the benthos, was found in most cases to be well within the range of natural fluctuations in background suspended sediment concentration (which is typically 100s to 1000s of mgl^{-1}). The only noted exception was dredging as bed preparation for GBS foundations where very localised increases in excess of natural variability are expected for short time periods (hours to days).

99. The lack of fine materials in the sediments of the Wind Farm Site means that the majority of material will settle out very locally, much of it within seconds (see Section 9: Wind Farm Physical Processes and Geomorphology) except in the case of drilling, where larger amounts of fine materials are anticipated that can be expected to be transported greater distances. Suspended sediment plumes related to the two alternative foundations installation methods investigated (seabed preparation for

gravity bases and drilling for jacket piles) appear broadly similar, with increases over background of 21 mgl^{-1} and 25 mgl^{-1} predicted respectively within 50 to 100 m of the Wind Farm, and falling to 10 mgl^{-1} within 100 to 200 and 50 to 100 m respectively; whilst the effects from cabling activities are predicted to be considerably smaller than this. Thus, the anticipated changes in suspended sediment concentrations for all three activities are typically an order of magnitude lower than background, short term, and mostly very localised around the seabed construction activities.

100. Interaction between plumes generated by the different construction activities seems likely to be very small since the seabed preparation and drilling activities are mutually exclusive (each foundation may require one or the other but not both) and there are obvious limits in the degree to which multiple installation activities will be possible. The localised nature of the effects means that sediment plumes from cabling activities will have very little interaction with sediment plumes from construction activities, as described in Section 9: Wind Farm Physical Processes and Geomorphology.

Assessment

101. There are no known communities or species in the study area that are thought to be very sensitive to changes in suspended sediments. It is therefore assessed that the small changes in suspended sediment concentrations expected here will not materially affect any of the benthic organisms or communities present in or adjacent to the Wind Farm Site, and that any effects are therefore of negligible significance.

102. In theory, plumes of suspended sediments also have the ability to affect receptors outside of the study area, such as the potentially important populations of slow growing bivalve *Arctica islandica* which have been reported some 2 to 16 km south west of the Wind Farm Site in the region of the Beatrice oil field. *A. islandica* was described earlier as being tolerant of raised levels of suspended sediments (using as a benchmark a change of 100 mgl^{-1} for 1 month). The small, short term and very localised changes in suspended sediments that have been identified as arising from worst case installation activities, and which are expected to be within the range of natural suspended sediment concentrations, are not expected to affect these distant populations in any way, however, and so the anticipated effects are of negligible magnitude at most, and are of negligible significance. The effect is therefore not significant in terms of the EIA Regulations.

10.4.1.3 Sediment Deposition

103. Drilling for jacket pin pile foundations (based on the unlikely scenario of drilling being required for every pile) has been described in Section 9: Wind Farm Physical Processes and Geomorphology and along with cable trenching by jetting provides the highly conservative worst case scenario.

104. Should the drilling scenario be progressed, there is expected to be relatively deep deposition of sandy material (up to 5 m very worst case estimate) within 50 – 100 m of each foundation and potential deposition of finer material to up to 0.9 mm depth (more likely 0.01 – 0.15 mm) in discrete sink areas outside of the Wind Farm Site.

The rate of accumulation in remote sinks is expected to be up to around 0.025 mm per month and in practice total accumulation will be limited by storm events.

105. The deposited sandy sediments are likely to develop communities that are mostly infaunal in nature, and therefore likely to be at least broadly similar in nature to the existing communities (there are areas where sessile epibenthic species are more prominent, these would be more susceptible to sediment deposition but only occur in limited areas within the Wind Farm and do not occur at sediment sink sites). How similar these will be will depend upon the exact nature of the sediments in recipient areas.

106. Accumulation of sediments to sinks outside the Wind Farm Site, assuming the conservative accretion of up to 0.9 mm of material (typically 0.01 to 0.15 mm) is low, and Section 9: Wind Farm Physical Processes and Geomorphology does not consider that these represent any change of a magnitude exceeding natural variability. Potential effects to benthic ecology are assessed below.

107. Section 9: Wind Farm Physical Processes and Geomorphology outlines several scenarios for sediment deposition resulting from cable trenching. The worst case scenario, jetting to achieve burial in 3 m wide/2.5 m deep trenches, is determined to result in relatively small accumulations in comparison to natural variability. Nonetheless, accumulations in excess of 5 cm (the standard depth used by MarLin in describing sensitivity to smothering effects, see Section 10.3) may extend for some tens of metres. As noted in Section 9: Wind Farm Physical Processes and Geomorphology, Royal Haskoning and Bomel Ltd (2008) have reported that previous cable installation works elsewhere have resulted in low levels of sediment disturbance and deposition; these authors further report only localised and temporary effects on benthic fauna in sandy areas, although this appears to be based on assumptions of lower levels of sediment movements than may be expected here. Effects on benthic organisms would be temporary since the resultant seabed character would not be changed and recolonisation would be expected within a timescale of six months to four years (as determined in relation to other effects, above).

108. The main receiving environment for fine material to the south of the Wind Farm Site is known to be considerably more muddy than the actual site itself. The extensive studies in support of the Beatrice oil field developments (e.g. Hartley and Bishop, 1986) which lies slightly to the north of the main areas of anticipated deposition found mostly 2.5 to 5% mud[3] content, in contrast to the Study Area where no samples had more than 2% and very few more than 0.5%.

109. Slightly further south the OfTW corridor survey found the sediment in the region of the main anticipated deposition to be predominantly moderately sorted to moderately well-sorted fine sands, but with a mud content determined by PSA of circa 5 to 8%, whilst the deeper waters at and beyond the eastern and southern

[3] Mud is defined as all fine material less than 63um, i.e. all silts and clays

edges of the anticipated receiving environment have higher mud contents in the range of 20 to 60% (Section 22: Offshore Transmission Works Benthic Ecology). However, the deep area of muddy sediments was characterised by the biotope S. SMu.CFiMu.SpnMeg sea pens and burrowing megafauna in circalittoral mud, albeit with a low density of sea pens. This biotope is considered a possible PMF, and is therefore of high importance. Apart from small numbers of seapens, virtually no fauna were observed in these areas during the OfTW survey, which used primarily camera survey supplemented by 17 sediment samples. The fauna was in all cases very strongly dominated by infauna, with no evidence of any species likely to be particularly sensitive to deposition of fine sediments.

110. In theory, these main remote receiving environments could typically receive a total of around 0.01 to 0.15 mm of fine material, although up to around 0.9 mm in any one place is the maximum estimate based on highly conservative assumptions. However, these are the maximum total amounts of deposits that can be expected over the three year construction period, and inevitably there is likely to be a large but unquantified degree of resuspension and dispersion of any settled sediments during that three year period, as well as incorporation into the existing sediments by bioturbation (the reworking activities of the fauna). These processes would, of course, continue after the cessation of construction.

111. The communities in these main depositional areas clearly inhabit sediments that are known to already contain reasonably high levels of muds, with levels mostly in the range 5 to 8%, and in the range 20 to 60% in places, so that major effects are unlikely. Important populations of the possible PMF *Arctica islandica* may overlap these areas, but this species is known to inhabit a range of sediments including sandy muds, where more than 50% of the sediment is composed of muds (Sabatini et al, 2008), and there can therefore be a high confidence that these animals will not be affected.

112. Further south, very muddy communities dominated by seapens may partially overlap the main depositional areas, but there can again be a high confidence that this community would not be detrimentally affected by the anticipated deposits. However, in those limited areas where deposits are anticipated to be highest, the possibility of some temporary changes to community structure (i.e. an increase in proportion of species tolerant of fine sediments at the expense of others less tolerant) cannot be completely ruled out. On present information, the timescale over which this is likely to occur is not known.

113. More widely, including within the Wind Farm, the total expected deposition over the three year period is much lower. These deposits are not expected to have any noticeable effect on the local seabed communities. Although the commercially fished great scallop *Pecten maximus* is known to grow faster on sediments with little mud, even this species regularly inhabits substrates with some admixture of mud (Brand, 1991), and is expected not to be affected by such small deposits. Queen scallops *Aequipecten opercularis*, which were more abundant than great scallops in beam trawl samples, regularly inhabit fairly muddy habitats such as sealochs and are similarly unlikely to be affected.

Assessment

114. The levels of fine sediments that are anticipated from the worst case scenario of drilling are extremely unlikely to have detectable effects upon the main benthic receptors outside of the Wind Farm Site, including potentially important communities of *Arctica islandica* and seapen dominated communities. Species and communities likely to be affected are in the main likely to be tolerant of moderate to high levels of muds within the sediments, i.e. their sensitivity to the anticipated effects is low. However, temporary effects on some seabed communities within limited areas to the south west of the Wind Farm Site, where deposits are expected to be highest, cannot be completely ruled out, but the effects are considered likely to be no more than negligible in magnitude and therefore of not more than negligible significance for any receptor. Negligible effects are not significant in terms of the EIA Regulations.

115. Inside the Wind Farm area the effects are potentially of a greater magnitude since although recovery would be expected to occur within around six months to four years temporary loss of infauna if inundated with tens of cm to 5 m of sediment within 100 m of the turbine. The most sensitive receptor is the encrusted cobble (PomB) biotope (low importance but susceptible to smothering). Conservatively, a medium magnitude effect is predicted for this receptor, resulting in a minor significance effect. No effects of greater significance are anticipated to other benthic receptors through this effect (NB MoeVen is a high importance receptor but with very low sensitivity to smothering). The effect is not significant in terms of the EIA Regulations.

10.4.1.4 Noise During Construction

116. There is little information on the effects of loud underwater noises on marine invertebrates. However, most marine invertebrates lack air filled spaces, and can thus only perceive sound as a physical force using sensory structures such as statocysts and hairs. Sound therefore has a limited likelihood of having physiological or behavioural effects on marine invertebrates. McCauley (1994) found little evidence of either behavioural or physiological effects, except in cases where the organisms were within a few metres of a powerful noise source. Noise levels of around 250 dB at 10 to 120 Hertz (Hz) have been reported from seismic air guns (Richardson et al, 1995) and associated short term behavioural effects upon marine invertebrates within a distance of around ten metres have been reported (McCauley, 1994; Brand & Wilson, 1996). These include bivalves withdrawing their siphons, and polychaete worms retracting their palps into their tubes, or moving rapidly to the bottom of their burrows.

117. The noise assessment has been made with the same worst case assumptions used for fish and marine mammal assessments (see Section 11: Wind Farm Fish and Shellfish Ecology and Section 12: Wind Farm Marine Mammals respectively) i.e. hammer piling of 2.4 m diameter pin piles for turbines plus 3 m pinpiles for OSPs and 1.5 m monopiles for meteorological masts. Pile driving is a medium term effect; noise modelling was based on two years of continuous piling) with periods of piling

generally lasting for up to a few hours with typically one hammer blow every few seconds or so, resulting in a pulse of sound that lasts for a few milliseconds.

118. A source noise level of 245dB re 1µPa peak-to-peak has been calculated for the installation of the 2.4 m diameter pin piles using a 2300kJ hammer at the Wind Farm (see Section 7: Project Description), and it is considered that this source of noise will be by far the most important of those likely to be encountered by benthic marine invertebrates. It is not known whether marine invertebrates have any ability to perceive the direction of sounds, so the Wind Farm application of 'soft start' is therefore unlikely to be of any benefit even to the more mobile invertebrates.

Assessment

119. The high-pressure wave generated by the source noise is assumed to be able to cause physical damage to invertebrates in the immediate vicinity, but if so this will be limited to a distance of a few metres at most. This is considered to be an extremely small, temporary effect that is assessed as being of negligible magnitude for all benthic marine invertebrates and hence of negligible significance (and would in any case fall well within the area assessed in Section: 9 Wind Farm Physical Processes and Geomorphology as being subject to permanent loss of seabed, and therefore represent no additional effect to what has already been assessed).

10.4.1.5 Release of Chemicals

120. It is normal practice to pump cement based grout into any gap between piles and the transition pieces, and a release of small amounts into the surrounding water is likely as the gap fills. However, the depth of the water and the high dispersion characteristics of the area mean that such small amounts will have very small effects by the time they reach the seabed, and any large aggregations of grout that reach the seabed are in any case almost certain to land on areas of seabed that have already been assessed as being permanently lost beneath the foundations and associated scour protection. Any accumulations of grout that did build up on substructures, scour protection or the seabed would be colonised in time as any other cement based substrate, but would probably require some soak time for the surface to become suitable for colonisation.

121. All major components are manufactured on land, thus limiting the potential for release of any other chemicals to things such as spillage of machinery lubricants and the fuels required for ships and equipment. Moreover, the project proposes the development of an environmental management system, including a suite of management plans for all major construction operations carried out at sea. This should further reduce the likelihood of any spills.

122. No evidence of raised levels of any hydrocarbon or metals in the sediments that might have been associated with, for example, hydrocarbon exploration were found in the Study Area. No potential for such contaminants to be released into the surrounding environment by disturbance of the existing sediments is therefore anticipated.

Assessment

123. The overall effect of release or spillage of chemicals on the benthic ecology is considered to be negligible in magnitude and is therefore assessed as an effect that is of negligible significance. This is not significant in terms of the EIA Regulations.

10.4.2 OPERATIONAL EFFECTS

10.4.2.1 Loss of Habitat

124. The most direct effect of installation of foundations is the complete loss of existing habitat that lies beneath the introduced structures. In this regard the worst case scenario is the option of 277 x 3.6 MW turbines each with a gravity base and associated scour protection (along with three OSPs), since this scenario gives the maximum total area of habitat loss. Data from the Rochdale Envelope, as explained in Section 7: Project Description of this ES, indicate that under this scenario a total of 11,690 m^2 will be permanently lost at each turbine location, along with 12,115 m^2 at each AC OSP, 45,100 m^2 at the DC converter. In total, this represents an estimated maximum area lost of 3.307 km^2, or approximately 2.52% of the seabed within the Wind Farm Site.

125. In addition, up to 0.4875 km^2, or approximately 0.371% of the seabed within the Wind Farm Site, could be lost as a result of the cable protection that may be required along the inter-array cables in areas where conditions do not allow burial.

126. The worst case total area lost to all turbine and OSP foundations, plus all associated scour protection and cable mattresses is, therefore, 3.8 km^2, or just under 2.9% of the total seabed within the Wind Farm Site.

127. According to the physical processes assessment, in the Wind Farm Site the sediments in the upper few metres are generally homogeneous, and for this reason it is here assumed that seabed losses associated with the cable protection are evenly spread throughout the area. Given that the area lost to the worst case assumptions for foundation types is almost seven times larger than that associated with the worst case assumptions for cable protection, any deviation from this is not likely to have a large effect on the assessment.

128. Given the large areas covered by most of the biotopes or biotope complexes, it is mostly reasonable to infer that this percentage represents the likely percentage loss for each, with the exception of the PomB biotope, which is discussed further below.

Assessment

129. The MoeVen biotope is conservatively considered to be of high importance, but 2.9% loss represents a small magnitude of effect, resulting in a permanent negative effect of moderate significance.

130. The MedLumVen biotope and Circalittoral fine sand biotope complex are considered to be of medium importance. Given that 2.9% loss represents a small magnitude of effect that results in a permanent negative effect of minor significance.

131. The PomB biotope is very limited in extent, with only a single well identified area of 0.021 km^2 within the Wind Farm Site. There is, therefore, the theoretical possibility

that all, or virtually all, of the known PomB biotope could be permanently lost if a gravity based OSP or turbine coincides directly with the area. However, it should be noted that the scour protection around all of the foundation supports may comprise loose rocks that are likely to support populations somewhat similar in nature to those already existing on the stones in this biotope, but will be much more extensive. Moreover, barnacles and encrusting tubeworms, along with other fauna occurring in this biotope, are known to be amongst the most dominant fauna encrusting hard surfaces in the Moray Firth, so that similar, though more stable and hence probably richer, communities are likely to develop if mattresses are used. It is therefore assessed that in the context of the Study Area as a whole the overall magnitude of effect is small, and given the low importance of the biotope this results in a permanent negative effect of minor significance. Minor effects are not significant in terms of the EIA Regulations.

10.4.2.2 Scour Effects

132. Because the worst case scenario in terms of substructure and foundations is considered to be the permanent loss of seabed beneath gravity bases and associated scour protection, the effects of scour around turbine supports is not assessed here.

133. However, the options presented for installation of inter-array cables do not present a clear worst case for benthos. Whilst scour protection is being considered for some areas of unburied cables, it is not certain that this will be employed and so the possibility of scour effects around unburied cables must be assessed.

134. The assessment of physical processes concludes that scour around exposed cables will be a slow process resulting in loss of a few centimetres of surface sediment extending to a few metres either side of the cable, and in predominantly sandy areas (which constitute the vast majority of the seabed on the Smith Bank) with no change in the nature of the remaining sediment. In more gravelly areas the proportion of gravel may increase as sand is effectively winnowed out. However, the worst case assumption has already been made earlier that coarser areas of seabed, which is more likely on parts of the MedLumVen biotope as well as the PomB biotope, will require rock dumping or mattressing, which will result in permanent loss of seabed communities associated with up to 50% of the total inter-array cable length. Scour effects in relation directly to surface laid cables are, therefore, assessed for the sandier sediments only. However, on coarser seabeds where rock dumping or mattressing is used, this is likely to create a similar localised scour of its own.

Assessment

135. The scouring process is anticipated to be slow, and in the sandy areas, which constitute the majority of the areas including the MoeVen biotope and circalittoral fine sand biotope complex, it is expected that this will result in no change to the nature of the remaining sediment. Seabed communities will not, therefore, be materially affected and in these areas the effect is considered to be of negligible magnitude and hence of negligible significance. This is not significant in terms of the EIA Regulations.

136. The rocky and scour tolerant PomB biotope is unlikely to be affected, so the effect is considered to be of negligible significance. In gravelly areas with considerable sand content such as parts of the MedLumVen biotope there may be some coarsening of the remaining sediment over time within a few tens of cm of emplaced scour protection that may result in slight changes to the nature of the community. Alternatively, there could also be limited increase in sand content very locally to the scour protection under some circumstances (Section 9: Wind Farm Physical Processes and Geomorphology). In either case it is unlikely that this would be very dramatic. In the main the nature of the communities will probably be little affected but in some places gradual increased long term coarsening or fining may occur. These will be long term but very localised effects on the MedLumVen biotope, which is of medium importance, but because the magnitude of the effect is thought to be very small, it is considered to be of minor significance. This is not significant in terms of the EIA Regulations.

10.4.2.3 Changes to Water Movement

137. The assessment in Section 9: Wind Farm Physical Processes and Geomorphology concludes that, under a worst case scenario based on gravity based turbines, changes in current speeds are extremely low and not considered to be significant; for example, a reduction of less than 0.01 ms^{-1} in peak speeds at spring tides, against a depth averaged mean spring tide speed presently of 0.55 to 0.6 ms^{-1}. These changes are anticipated mainly within the Wind Farm Site but may extend up to 3 km on the flood tide (i.e. towards the Inner Firth) and 5 km on the ebb tide (i.e. towards the Outer Firth).

138. Based on the same worst case scenario, maximum wave height (based on significant wave height over several time periods ranging from 1 to 50 years) within the Wind Farm will be reduced by between 0.35 and 1.1 m, representing between 5 and 15% reduction in maximum wave height, with the greatest changes being for waves from 45^{o} N i.e. along the long axis of the Wind Farm. However, this effect will vary considerably within the Wind Farm Site, with the maximum value of 15% reduction experienced only over a very limited extent of 1 km extent or so at the south west end of the site (on MoeVen biotopes). Half of the Wind Farm Site is expected to show a much smaller reduction in maximum wave heights of less than 7.5%, and one quarter of the site will experience reductions in maximum wave heights of less than 3.75%. Smaller waves are expected to be affected to a much lesser degree. Beyond the Wind Farm, the reduction in maximum wave height experienced will change in a non-linear fashion, i.e. recovering quickly over small distances but with some residual effects over larger distances. Wave periods are expected to show only very small changes of up to plus or minus 3 to 5% at most.

139. Filter feeding members of the seabed community, which are probably slightly more prevalent in the PomB and MedLumVen biotopes than the other biotopes, are dependent upon water movement in order to provide a supply of food. However, the anticipated changes are extremely unlikely to make any meaningful difference in this regard.

140. Potential reduction in the degree to which sediments are mobilised might be also expected to influence seabed communities. In this regard wave period, rather than simply wave height, might also be an important factor, since longer waves are more likely to penetrate to the seabed. Based on combined changes to waves and currents, the assessment of physical processes concludes that there will be only minor changes in the textural properties of the seabed sediments, and that any changes to seabed sediment processes, such as mobilisation and transport of sediments, will be small and less than the potential for natural variability. According to figures presented in the Section 9: Physical Processes and Geomorphology fine and medium sands, which are the predominant sediments in the Wind Farm application area, are presently mobilised approximately 2 to 4% if the time, and following development are expected to be mobilised for approximately 20% less time. Effects such as reduced physical scouring by sediment particles, marginally increased feeding opportunities for filter feeding members of the community, due to lack of clogging by suspended sediments during periods of high water movement, or marginally reduced feeding efficiency due to lower levels of suspended detrital food particles, may theoretically occur, but given the very low levels of changes anticipated are extremely unlikely to be sufficient to cause detectable changes to the communities.

141. Of the identified seabed communities the most sensitive receptor might be expected to be the PomB biotope, the nature of which is heavily influenced by the effects of water movement on the stony substrate – although this probably relates more to the rolling around on the seabed of pebbles and stones, than to scouring by smaller particles. This action prevents the establishment and growth of many organisms, so that the community is dominated by scour tolerant fauna such as calcareous tubeworms, barnacles and certain bryozoan species. The small areas of PomB found within the Wind Farm were found not to be perfect matches with this biotope, being slightly richer in places, suggesting scouring is not particularly severe. In the event that these small anticipated changes reduce overall scouring effects further there might conceivably, therefore, be some further very small trend towards enrichment of this biotope in numbers of species and biomass, but based on the anticipated level of changes this seems unlikely to be a measurable effect.

Assessment

142. The anticipated changes to both current and wave regimes, and their effects on seabed sediments, are mostly small, and not anticipated to be outwith the range of natural variability on annual or decadal timescales even within the Wind Farm Site. At the regional scale, such as at coastal areas of the Moray Firth, they are unlikely to be even measurable in practise in most cases. They are not, therefore, expected to cause detectable changes in any of the seabed communities present either within the Wind Farm Site, or elsewhere in the Moray Firth.

143. Any effect on seabed communities of changes to water movement by currents and waves is therefore considered to be of negligible magnitude and hence of negligible significance. This is not significant in terms of the EIA Regulations.

10.4.2.4 Creation of New Habitat

144. The introduction of the concrete gravity base foundations and rock scour protection represents the worst case scenario for loss of benthic habitat represents new habitat which will be colonised by a wide variety of marine organisms. There is a considerable literature documenting the often rapid and dense colonisation of a very wide range of artificial structures. Examples from UK waters included radio masts, meteorological monitoring masts, oil and gas drilling and production platforms and other structures (many of which are sources of considerable noise and vibration) and, increasingly, turbine foundations, and there are well studied examples from the Beatrice oil platform supports in the Moray Firth. A wide variety of encrusting organisms is reported, of which the most abundant include mussels, tubeworms, barnacles, hydroids, sponges, soft corals, amphipods, anemones and other sessile invertebrates, as well as more mobile fauna including starfish and crabs and sometimes seaweeds (e.g. Vella et al, 2001; Bio-consult, 2000; Innogy, 2002; Picken, 1986).

145. The speed with which colonisation can occur has been regularly illustrated, e.g. the case of a monitoring monopile at the Horn's Rev wind farm site off the coast of Denmark which was largely colonised by bryozoans, sea anemones, sea squirts, starfish and a few common mussels *Mytilus edulis* after only five months (Bio-consult, 2000), although winter storms subsequently scoured everything clean. After about one year dense colonisation of monopiles at the North Hoyle offshore wind farm in the Irish Sea was observed, with large numbers of barnacles, common mussel *Mytilus edulis,* tube dwelling amphipods and common starfish (MarineSeen, 2004).

146. Within the Moray Firth, virtually the whole of the supports of the Beatrice Oil Platform exhibited very dense colonisation by calcareous growths of tubeworms (*Hydroides norvegica* and *Pomatoceros triqueter*) and barnacles (*Balanus balanus*, *B. balanoides* and *B. crenatus*) in less than 12 months (Picken, 1986). By year three mussels *M. edulis* dominated over one third of all available surfaces, but by year four mussels and seaweeds were dominant from 0 to 5 m, and the background calcareous layer was overgrown by the soft coral *Alcyonium digitatum* and a variety of hydroids (8 to 35 m), or hydroids and ascidians (from 35 m to the seabed at 46 m). The Beatrice oil platform has several horizontal cross members as well as the vertical legs, and it was noted that the soft corals and ascidians grew larger on the lower surfaces of cross members than the upper, which was presumed to be a result of lower siltation rates.

147. A variety of mobile crustaceans tend to be found at the base of towers, including the edible crab *Cancer pagurus*, hermit crabs *Pagurus* sp, and long legged spider crab *Macropodia rostrata* and, at least in shallower areas, the brown shrimp *Crangon crangon* and other crabs such as shore crab *Carcinus maenas*, (Bio-consult, 2004a). Small tube-dwelling crustaceans can sometimes occur in very high densities in the spaces between fouling barnacles or mussels as reported at both Horn's Rev and North Hoyle wind farms, where in the latter case in particular they appeared to form an abundant food resource for small fish.

148. At Horns Rev rock based scour protection was reported to have a similar suite of species to the monopiles, though at different abundances (Bio-consult, 2004b).

149. In general, it can be seen that many of the more successful colonisers are filter feeders, which take advantage of the increased opportunities for feeding provided by high water flows, and which in turn support a variety of scavengers and predators such as starfish crabs, and fish. In many instances surveys have found a highly scoured zone on the lower parts of the supports (i.e. near the seabed) where colonisation is poor, the size and nature of which depends upon the local conditions such as the local sediment type, amount of water movement, and probably the degree of scour protection provided.

150. It is anticipated that broadly similar dense colonisation to that described above will occur on the turbine substructures in the Wind Farm, although, it is not clear exactly how the colonisation on concrete bases will compare with that on monopile structures. Concrete generally compares well with steel and other materials as a substrate for colonisation (Figley, 2003) although fresh concrete may require an initial soak period in seawater before substantial colonisation occurs. However, the design is clearly different to that of the more commonly used monopile supports used on all existing UK offshore turbines. The concrete structure presents faces oriented at a variety of angles to the vertical, and some parts of the structure may therefore be less advantageous for filter feeders, and may also be more subject to sediment deposition. On the other hand, scouring effects may be reduced by the sheer size of the structures, with severe scour perhaps being limited to the outer edges of the rock–based scour protection itself (note that 'scour' here refers to the removal of fauna from hard surfaces by, in effect 'sand blasting', whereas elsewhere scour is used to refer to the removal of seabed sediments around structures by severe water movements, potentially leaving a depression in the seabed).

151. Colonisation by marine organisms can also be expected to occur on any rock-based scour protection. The degree of surface complexity, and the amount and size of spaces and crevices between stones, will affect the attractiveness to colonising organisms (Pickering and Whitmarsh, 1997; Hoffman et al, 2000). Complex habitats provide a higher surface area for colonisation, protection from predators and shelter from stressful conditions such as intense water movement, and therefore usually develop richer and more diverse communities. The precise nature of the communities that will develop will be influenced by factors such as the size, shape, stability, and perhaps type, of the rocks used, as well as the depth and degree of water movement. Small stones which are moved frequently by storms or strong currents are likely to develop a fairly limited scour-tolerant fauna, for example encrusting barnacles, tubeworms or bryozoans, similar to the PomB biotope that exists in places presently, while a greater diversity of organisms would be likely on larger, more stable rocks. Other physical factors such as the amount of sediments settling on or between the stones, and unpredictable biological factors such as the numbers of recruiting larvae in the local water in any given period are also likely to be important.

152. The overall effect of installing the gravity foundations and rock based scour protection will be the replacement of areas of the existing predominantly sandy or slightly gravelly biotopes with communities typical of harder substrates. At a very local level this will increase the overall species diversity and productivity (e.g. Wickens and Barker, 1996; Grossman et al, 1997). At the Horn's Rev offshore wind farm, where the shallow water led to scouring that strongly limited the amount of colonisation, the epifauna on the monopiles nevertheless reached a biomass per unit area of seabed eight times that of the fauna in the surrounding sands (Bio-consult, 2004a). Other studies on fairly complex structures in temperate waters have shown an increase in biomass between 23 and 2195 times that of surrounding sandy substrates within a period of a few years (Figley, 2003). However, the structures considered here are relatively simple and with a high proportion of upward facing surfaces, though with a large surface area; in the absence of information on comparable structures it is assumed the biomass they support will be towards the lower end of these ranges.

153. Fish communities are assessed separately in Section 11: Wind Farm Fish and Shellfish Ecology, and so are mentioned only briefly here. It is widely reported that a variety of species can be found around both support structures and rock armour. The studies cited above suggest that pogge, butterfish, dragonets and scorpionfish amongst others can be expected to occur on scour protection, while flatfish such as plaice might attracted to the immediately adjacent areas, whilst butterfish plus shoaling gadoids such as whiting, bib and perhaps juvenile cod are likely to be found around the upright structures. MarineSeen (2004) found dense shoals of juvenile whiting apparently feeding on tube dwelling amphipods that were growing on monopiles at North Hoyle offshore wind farm approximately one year. However, a comprehensive review of existing studies found few studies that unambiguously demonstrated that artificial reefs increased regional fish production rather than merely concentrated available biomass (Grossman et al, 1997).

154. The turbines will be located in water mostly deeper than 35 m. This will probably allow many of them to develop relatively rich and diverse communities. Seaweed growth is likely to be less limited by turbidity on the Smith Bank than at the many of the existing wind farms, but will nevertheless be mainly restricted to the upper ends of the structures. Encrusting or tube-dwelling animals such as mussels, barnacles, anemones, soft corals and tube-dwelling amphipods are likely to dominate the majority of the submerged surfaces, but a variety of larger mobile organisms such as starfish, crabs, prawns, and small fish can be expected, particularly on more complex parts of the structures (such as external j-tubes) and the scour protection. Each structure would represent an increased area for epifaunal colonisation compared to the existing seabed, and will expose many animals to higher amount of water movement (and therefore better feeding opportunities) compared to when on the seabed, and it is therefore likely that the fouling community will be more productive per unit areas of seabed. There is less published information directly relevant to mattresses, but organisms similar to the larger boulders present in the area can be expected, for example a range of colonial

hydroids and bryozoans, along with some dead man's fingers, urchins, starfish, crabs and prawns.

Assessment

155. The effect of the addition of 280 gravity based installations would therefore be a localised increase in the overall diversity and productivity of the seabed communities, albeit of different species to those dominant in the area presently. The effect of the addition of up to 0.4875 km^2 of cable protection would be broadly similar although it is likely that these, like the scour protection, would probably develop a lower biomass per unit area of seabed than the gravity bases, but still likely to be considerably higher than the existing dominant habitats. These would be numerous localised, long term positive changes, most likely to be of medium overall magnitude. It is difficult to allocate importance to these communities but given that they are likely to largely constitute species that are common on hard subtrates in the northern North Sea they are considered here to be of low importance, and the effects are therefore of minor significance. This is not a significant effect in terms of the EIA Regulations.

10.4.2.5 Possible Stepping Stone Effect for Invasive Species

156. The potential addition of large amounts of new hard substrates in UK territorial waters has raised as an issue the possibility that this might increase the ability of invasive species to spread, by increasing the likelihood of dispersal phases encountering suitable areas for settlement. There is little or no useful published information on this subject which is therefore to a large degree speculative at present. Many of the more potentially serious examples of invasive species are presently associated with inshore estuarine areas or harbours and marinas (e.g. the carpet sea squirt *Didemnum vexillum*; the leathery sea squirt *Styela clava*; the Chinese mitten crab *Eriocheir sinensis* which occur on muddy estuarine seabeds, and others). In many cases it seems likely that introduction occurs as a result of shipping/boating activity, either as a result of fouling on ships hulls or from larval or reproductive stages in ballast water, but at least in some cases subsequent spread can subsequently occur via normal dispersion of larval or juvenile stages (e.g. the seaweeds *Sargassum muticum*, and *Undaria pinnatifida*; Pacific oyster *Crassostrea gigas*). There is no published or anecdotal evidence that the installation of large numbers of offshore platforms and pipelines in the North Sea in recent decades has led to a spread of invasive species. It is acknowledged that the density of structures within extensive wind farm areas such as the Wind Farm will be much greater.

Assessment

157. The effect of increasing the number of hard substrate areas in the form of foundations and sub-structures may theoretically increase the rate of spread of invasive species, but this is presently impossible to confirm or quantify. However, given the distance offshore, the longstanding existence of numerous artificial substrates associated with the offshore oil and gas industry both in the Moray Firth and further offshore, and the existence already of frequent, even if small and scattered, natural hard substrates in the form of cobble and boulders, it appears very

unlikely to make a difference to whether an invasive species reaches one part of Scottish waters from another. Theoretically it may increase the rate of spread slightly although there is presently no evidence for this. This potential effect is therefore conservatively considered to be at most of minor significance. This effect is not significant in terms of the EIA Regulations.

10.4.2.6 Operational Noise

158. In comparison to activities such as piling or seismic survey, operating turbines produce relatively low levels of noise and vibration, and there is little evidence that benthic invertebrates can detect these (Vella et al, 2001). Moreover, a wide variety of benthic organisms, both mobile and sessile, have proven capable of rapid and extensive colonisation of noise producing structures and surrounding seabeds. As well as numerous oil and gas platforms, such structures include operating wind farm installations, for example those at the Horn's Rev, Nysted and North Hoyle wind farms (Vella et al, 2001; Anon, 2004; Birklund and Petersen, 2004; MarineSeen, 2004, 2008). Thus, it seems extremely unlikely that any marine invertebrates would have a high sensitivity to the operational noise or vibration generated by offshore turbines (Vella et al, 2001).

Assessment

159. It is expected that there will be no detectable effects of noise or vibration from operation of the turbines on benthic organisms, and that any effects will therefore be of negligible significance. This effect is not significant in terms of the EIA Regulations.

10.4.2.7 EMF Effects

160. Inter-array cables will generate EMF in the surrounding seabed and water. No marine invertebrates have been demonstrated to be electrically sensitive. The anticipated electric fields induced from 33 kV cables are of relatively low strength and therefore unlikely to cause detrimental physiological effects on invertebrates, supported by anecdotal evidence of benthic invertebrates living on, or immediately adjacent to, HVDC cables. However, some benthic invertebrate species are known to be sensitive to magnetic fields, and could therefore be affected by the magnetic component of EMF. EMF effects on fish are assessed separately (see Section 11: Wind Farm Fish and Shellfish Ecology).

161. There is no clear worst case scenario for magnetic field effects on benthic organisms. It is here assumed to be the 277 turbine scenario, since this would involve the largest total length of cable. However, larger current loads might be carried by cables serving a smaller number of higher capacity turbines. These would lead to a higher electromagnetic field strength for a given cable operating voltage, but emanating from a lower overall length of cable, and the overall effects would be extremely unlikely to be noticeably different.

162. Potentially sensitive groups include crustaceans (such as crabs, shrimp and prawns) and molluscs (such as snails and bivalves). Most demonstrated examples of magnetic response in crustaceans and molluscs have been from outside UK waters,

but including species found inside UK waters; recent unpublished work in the UK suggests that the shore crab *Carcinus maenas* shows some response, to magnetic fields, however (Everitt, unpublished). It is therefore likely that some crustacean and molluscan species, including brown shrimps, present within the Wind Farm Site, will be magnetically sensitive.

163. Magnetic sensitivity has been demonstrated for decapod crustaceans (*Crangon crangon,* known to be present at low densities in the Study Area) as well as shore crabs (*C. maenas*) isopods (*Idotea baltica)* and amphipods *(Talorchestia martensii* and *Talitrus saltator*). In all cases, magnetic sensitivity is understood to be associated with orientation and direction finding ability. If animals perceive a different magnetic field to the earth's there is potential for them to become disorientated; depending on the magnitude and persistence of the confounding magnetic field the effect could be a trivial temporary change in swimming direction or, in theory, a more serious effect on migration. The distance over which this is likely to occur is generally considered likely to extend a few metres from the cable, and is not materially affected by burial, or otherwise, of the cable.

164. There is no evidence to date from monitoring at any wind farm that the distributions of potentially magnetically sensitive species of crustaceans and molluscs have been materially affected by the presence of submarine power cables and associated magnetic fields; moreover, healthy looking edible crabs *C. pagurus* have been seen within a few metres of AC cables on monopiles and on the immediately adjacent seabed within a year or so of installation (e.g. MarineSeen, 2004), whilst numerous mobile crustaceans including a variety of crabs and shrimps are known to have successfully colonised scour protection (e.g. Bio-consult, 2004a) although in these cases proximity to the cable is not known in detail. However, monitoring has not been designed to specifically investigate magnetic field effects on benthos and so some subtle changes in distribution of potentially sensitive species could have occurred.

Assessment

165. There is a possibility of an effect on some mobile benthic invertebrates. Uncertainties in this assessment relate to the magnitude of the magnetic fields that the Wind Farm will produce, especially from offshore substations where cables are in close proximity to each other, and the uncertainties about the ability of receptors to detect magnetic fields and the ecological significance of any effects. Nevertheless, the effect is considered to be of small magnitude since any effects would be sublethal, would affect very limited areas of sea bed, and would be intermittent (since magnetic fields will fluctuate with Wind Farm generating status). The mobile organisms such as crabs and shrimps that are most likely to be affected are not abundant on the site and are considered to be of low importance; this is thus considered overall to be an effect that is of negligible magnitude and thus of negligible significance. This effect is not significant in terms of the EIA Regulations.

10.4.2.8 Changes in Fishing Activity

166. The main demersal fishing activity on the Smith Bank is scallop dredging, which is well known to have the potential to cause damage to seabed communities. Although there are no particularly sensitive communities in the Study Area a large scale reduction in fishing pressure might be expected to have some benefits to the seabed communities, particularly those on coarser sediments, notably the MedLumVen community. However, the level of activity in the Study Area, whilst very variable from year to year, is considered to be low (see Section 16: Wind Farm Commercial Fisheries). There are several possible scenarios for future fishing within the Wind Farm Site, but none of these envisage an increase in fishing activity; however, it is possible that overall the fishing activity in the area may be maintained at current levels.

Assessment

167. From the perspective of seabed disturbance within the Wind Farm Site, no change in fishing activity is clearly the worst case scenario, and since it involves no change in effect on the benthos from the present situation, this is assessed as being of negligible significance. This effect is not significant in terms of the EIA Regulations.

168. Given the low and intermittent level of demersal fishing activity in the Wind Farm Site and the likelihood that some fishing will be able to resume within the Wind Farm Site once operational, the fishing assessment does not anticipate a large increase in fishing pressure in areas outside of the Wind Farm Site due to displaced activity (see Section 16: Wind Farm Commercial Fisheries). Effects on benthic habitats or species outside of the Wind Farm Site due to displaced fishing are, therefore, assessed as of negligible significance. This effect is not significant in terms of the EIA Regulations.

10.4.3 DECOMMISSIONING EFFECTS

10.4.3.1 Noise and Vibration

169. Detailed methods for the decommissioning phase have yet to be developed, however, it is assumed here that turbines and their associated structures would be removed by lifting (gravity bases) or by cutting them off at the seabed (piles) (see Section 7: Project Description). The dismantling of Wind Farm structures will generate noise from the use vessels and cutting machinery if used, but the sound levels from such machinery is not anticipated to be greater than those assessed under the construction effect section.

Assessment

170. The effect on benthic invertebrates is therefore predicted to be of negligible significance. This effect is not significant in terms of the EIA Regulations.

10.4.3.2 Disturbance of the Seabed

171. It is assumed here that all structures and substructures will be removed down to the natural seabed level, using broadly similar vessels and methods as for construction. It seems unrealistic to assume that rock based scour protection will be removed. It

is likely that the removal process will involve fewer jack-up barge emplacements than construction, since extensive seabed preparation will be unnecessary, fewer 'lifts' are likely to be required for removal of structures than installation, and rock based scour protection around structures is assumed to be left in situ. However, in the absence of any detailed information, a worst case scenario is assumed here, whereby the effects of decommissioning are considered to be similar to broadly similar to those of construction.

Assessment

172. The PomB biotope is likely to be particularly tolerant of many of these disturbances, and the MedLumVen biotope to be the least tolerant as described earlier, but even the latter can be expected to recover fully over periods of a few years. For all of the benthic communities present, seabed disturbance during decommissioning is considered to be an effect of very small magnitude in the context of the region as a whole. For the MoeVen community, which is considered to be of high importance but has a high ability to recover from such effects, this results in a negative effect of minor significance; for the MedLumVen biotope (medium importance) a negative effect of minor significance, and for the PomB biotope and circalittoral fine sand biotope complex (low importance) a negative effect that is of negligible significance.

10.5 MITIGATION MEASURES

173. There are no practical mitigation measures that can be put in place to reduce any of the anticipated effects described in Section 10.4 above. The most significant effects result from direct loss of sandy seabed habitat supporting a MoeVen biotope as a result of the emplacement of gravity based foundations and associated scour protection, along with rock or concrete based cable protection. There is no feasible option for mitigating these losses.

10.6 RESIDUAL EFFECTS

174. Residual effects are the same as the effects described in Section 10.4 above.

10.7 MONITORING AND ENHANCEMENTS

175. A program of benthic monitoring will be agreed with the relevant authorities and is likely to include the following main elements:

- Monitoring of infaunal benthos using a series of replicated grab samples within and outside of the Wind Farm Site, the aim of which would be to detect any changes that can be attributed to the development of the Wind Farm itself. This would include associated analysis of sediment particle sizes, as changes to sediments are the most likely cause of any faunal changes. The survey design would ensure that the major biotopes present in the area were each included; and
- Monitoring of larger and more mobile benthic organisms using scientific beam trawls within and outside of the Wind Farm Site, the aim of which would again be to detect any changes that can be attributed to the development of the Wind Farm itself. Since these will also sample smaller demersal fish this element would be integrated with any fish monitoring.

10.8 SUMMARY OF EFFECTS

176. The results of the assessment in relation to benthic invertebrate receptors are summarised below and in Table 10.5.

177. Construction effects are primarily related to disturbance of up to around 0.33% of the seabed each year during preparatory activities for gravity base foundation from the legs of jack-up rigs and anchors during installation, and from the effects of cable installation machinery such as jetters, ploughs or trenchers. Deposition of fine sediments in areas to the south west of the Wind Farm Site following these activities may also have some limited effects on muddy sand communities living in those areas.

178. Operational effects are primarily from the direct loss of up to around 2.9% of the existing sand, gravel and cobble habitats, and their replacement with turbine foundation structures and scour protection that can be expected to be rapidly colonised by a variety of organisms. Slightly increased rates of transfer of invasive organisms via the new hard substrates cannot be ruled out and are therefore considered of potential minor significance.

Table 10.5 Summary of Potential Effects on Benthic Invertebrate Receptors

Effect	**Predicted Significance**	**Mitigation Proposed**	**Residual Effect Significance**
Wind Farm: Construction			
Disturbance of the seabed	Minor significance for MoeVen biotope Minor significance for MedlLumVen biotope Negligible significance for PomB biotope and Circalittoral fine sand biotope complex	No	Minor significance for MoeVen biotope Minor significance for MedlLumVen biotope Negligible significance for PomB biotope and Circalittoral fine sand biotope complex
Increase in suspended sediment concentrations	Negligible significance	No	Negligible significance
Sediment deposition	Minor significance for PomB biotope and negligible significance for other biotopes or biotope complexes within the Wind Farm area Negligible significance in potential depositional areas to the south west of the Wind Farm area.	No	Minor significance for PomB biotope and negligible significance for other biotopes or biotope complexes within the Wind Farm area Negligible significance in potential depositional areas to the south west of the Wind Farm area.
Noise during construction	Negligible significance	No	Negligible significance

Effect	Predicted Significance	Mitigation Proposed	Residual Effect Significance
Release of chemicals	Negligible significance	No	Negligible significance
Wind Farm: Operational Phase			
Loss of habitat due to placement of foundations and scour protection, including over cables	Moderate significance for MoeVen biotope Minor significance for MedLumVen biotope and circalittoral fine sand biotope complex Minor significance for PomB biotope	No	Moderate significance for MoeVen biotope Minor significance for MedlLumVen biotope and circalittoral fine sand biotope complex Minor significance for PomB biotope
Scour effects	Scour effects from turbine foundations would be within the area assessed as permanently lost habitat under worst case scenario Scour effects from scour protection associated with cable protection would be of negligible significance for circalittoral fine sand biotope complex, MoeVen biotope and PomB biotope; and of minor significance for MedLumVen biotope	No	Minor significance for MedLumVen biotope Negligible significance for other biotopes
Changes to water movement	Negligible significance	No	Negligible significance
Creation of new habitat	Positive changes of minor significance	No	Minor significance
Possible stepping stone effect for invasive species	Minor significance.	No	Minor significance
Operational noise	Negligible significance	No	Negligible significance
EMF effects	Negligible significance	No	Negligible significance
Changes in fishing activity	Negligible significance	No	Negligible significance
Decommissioning Effects			
Noise and vibration	Negligible significance	No	Negligible significance

Effect	Predicted Significance	Mitigation Proposed	Residual Effect Significance
Disturbance of the seabed	Minor significance for MoeVen biotope Minor significance for MedlLumVen biotope Negligible significance for other biotopes or biotope complexes	No	Minor significance for MoeVen biotope Minor significance for MedlLumVen biotope Negligible significance for other biotopes or biotope complexes

10.9 ASSESSMENT OF CUMULATIVE EFFECTS

10.9.1 INTRODUCTION

179. Given below is the assessment of cumulative effects upon benthic ecology arising from the Wind Farm in conjunction with other existing or foreseeable planned project/development activities.

180. A CIADD (MFOWDG, 2011) was produced which set out the developments to be considered and the assessment method for each technical assessment and is the basis of this assessment. The CIADD is presented in Annex 5B.

10.9.2 SCOPE OF ASSESSMENT

181. The scope and method of this assessment was previously described in the CIADD (MFOWDG, 2011). This remains unchanged from the method presented in the CIADD (Annex 5B).

182. The assessment of significance of cumulative effects has used the same criteria to determine significance based on the sensitivity of the receptor and the magnitude of the potential change as presented in Section 10.2.

183. The assessment of cumulative effect has been made against the existing baseline conditions as presented in Section 10.3.

10.9.3 CONSULTATION

184. The CIADD (MFOWDG, 2011) was presented to Marine Scotland for review in April 2011 for comment.

185. Cumulative assessment methods were scoped with a wide variety of consultees including Marine Scotland and SNH. Consultation responses were summarised above in Table 10.1.

10.9.4 GEOGRAPHICAL SCOPE

186. The CIADD (Section 4.3.6) stated that the study area with regard to cumulative benthic effects should be initially considered as the whole Moray Firth; however it was also stated "this was likely to be refined following review of the results of the assessment of potential cumulative effects on sediment and coastal processes". In practise, effect pathways with the potential to have cumulative effects from outside the Moray Firth are assessed in Section 9: Wind Farm Physical Processes and Geomorphology, outcomes of which are used here where relevant.

187. The results of the assessment presented throughout Section 10.3 have been considered in determining which developments have been assessed for cumulative effects and are described below.

10.9.5 DEVELOPMENTS CONSIDERED IN ASSESSMENT

188. Section 4.3.8 of the CIADD (MFOWDG, 2011) (Annex 5B) presented the developments for which it was considered an assessment of cumulative effects with the BOWL project should be undertaken for benthic ecology. These were:

- BOWL Generating station;
- Moray Firth Round 3 Zone Eastern Development area;
- Moray Firth Round 3 Zone Western Development area;
- BOWL OfTW cable;
- Moray Firth Round 3 Zone OFTO cable;
- Proposed SHETL cable;
- Proposed SHETL hub;
- Any relevant port and harbour activities in the Moray Firth;
- Relevant oil and gas activities;
- Dredging and sea disposal in the Moray Firth; and
- Commercial Fisheries.

189. As a result of the scoping exercise on cumulative assessment, there was a request to investigate the possibility of cumulative effects on benthos from military exercises.

190. The main potential project that might be perceived to have cumulative effects is the proposed Moray Firth Round 3 Zone development due to its large size and close proximity. In addition there is the SHETL cable hub which has been considered in Section 9: Wind Farm Physical Processes and Geomorphology and is included here where possible cumulative effect pathways have been identified in that section. Several other, more distant, developments have also been discussed in relation to several potential effect pathways in Section 9: Wind Farm Physical Processes and Geomorphology but were considered not to have any potential cumulative effects. New oil and gas infrastructure at the Polly Well (Beatrice field) was scoped out of cumulative assessment in Section 9: Wind Farm Physical Processes and Geomorphology but is nevertheless considered here in respect of operational effects (loss of habitat).

191. No port and harbour activities have been identified that have the potential to effect cumulatively on any of the benthic communities assessed here, and this topic is therefore not considered further. Similarly, no dredging and sea disposal activities have been identified that have the potential to effect cumulatively on any of the benthic communities assessed here and this topic is also not considered further here. These topics were also scoped out of cumulative assessment in Section 9: Wind Farm Physical Processes and Geomorphology.

192. The seabed communities identified within the Wind Farm survey area and along, and adjacent to, the OfTW cable corridor, represent the baseline conditions in the presence of existing levels of commercial fishing. The possibility of changes to the

benthos as a result of changes to commercial fishing patterns caused by development of the Wind Farm has already been assessed above in Section 10.4 as being of negligible significance. Given the low and intermittent level of demersal fishing activity in the Wind Farm Site and the likelihood that some fishing will be able to resume within the Wind Farm Site once operational, the fishing assessment does not anticipate a large increase in fishing pressure in areas outside of the Wind Farm Site due to displaced activity (see Section 16: Wind Farm Commercial Fisheries).

193. Section 9: Wind Farm Physical Processes and Geomorphology assessed effects from the viewpoint of the geomorphological features of the area. As part of this assessment the following developments were considered with regard to the disturbance of the seabed resulting in the release of sediment. It was assessed as all of the following developments/activities proceeding simultaneously:

- BOWL and Moray Firth Round 3 Zone foundation installation (drilling for pin piles or bed preparation for gravity bases);
- BOWL and Moray Firth Round 3 Zone inter-array cable burial;
- BOWL and Moray Firth Round 3 Zone transmission cable burial;
- Oil and gas foundation installation (drilling for pin piles or bed preparation for GBS); and
- SHETL cable burial.

194. Based on worst case scenarios for numbers and size of turbines in the Moray Offshore Wind Farm, Section 9: Wind Farm Physical Processes and Geomorphology also assessed possible cumulative effects from the point of view of changes to waves and currents.

195. The assessment in Section 9: Wind Farm Physical Processes and Geomorphology finds no significantly elevated effects in comparison to those assessed for the Beatrice Offshore Wind Farm alone for any of the topic areas assessed. Nevertheless, some differences are discussed within several of the topic areas within Section 9: Wind Farm Physical Processes and Geomorphology, and these have been used to inform the assessment of cumulative effects on benthic ecology.

196. The effects which have been assessed cumulatively with regard to benthic ecology have also been informed by the findings of the assessment of the Wind Farm presented in Section 10.4 above and the assessment of the OfTW presented in Section 22: Offshore Transmission Works Benthic Ecology.

197. Several potential effects on benthic receptors as a result of the construction or operation of the Wind Farm including OfTW have been assessed as being of negligible significance for all benthic receptors, and given the lack of potential for cumulative effects from other projects, these are not, reconsidered here. These are: noise (during construction, during operation and during decommissioning), release of chemicals; scour effects; possible EMF effects and changes in fishing activity. These potential effects were also found to be negligible in respect of the installation of the OfTW except for changes to fishing activity, which were not considered for that assessment.

198. Some other effects were assessed as being of negligible significance for all or most benthic receptors for the Wind Farm, but because there could in theory be potential pathways for cumulative effects, are nevertheless assessed here.

199. Potential cumulative effects on benthos that are assessed are therefore:

Construction effects

- Sediment deposition from construction activities in the proposed Moray Firth Round 3 Zone development;
- Disturbance of the seabed as a result of the proposed Moray Firth Round 3 Zone development and SHETL Hub; and
- Military activities. Potential direct effects on benthos of the bombing activity, if any, are not known in detail but are likely to be extremely localised, and affecting seabed communities that are both remote from, and probably quite different to, those at the Wind Farm Site. Noises from loud explosions are also considered.

Operational effects

- Direct loss of habitat (i.e. loss of habitat over wider areas as a result of the proposed Moray Firth Round 3 Zone development, Polly Well and SHETL Hub;
- Changes to water movement; and
- Possible stepping stone effects of additional developments, particularly the Moray Firth Round 3 Zone development.

10.9.6 WORST CASE SCENARIOS

200. The proposed Moray Firth Round 3 Zone development is the main potential source of cumulative effects on benthic ecology to those from the Wind Farm development. There are presently a variety of possible development options for the proposed Moray Firth Round 3 Zone development, and it is therefore necessary to identify, as far as possible, the worst case scenarios from current available information.

201. The worst case scenario for direct loss of seabed habitat from the Moray Firth Round 3 Zone development is derived from a combination of information provided by Moray Firth Round 3 Zone regarding turbine numbers and foundation size, and conservative assumptions made by BOWL regarding the likely extent of scour protection. Whilst it is accepted that the worst case presented here may represent an overestimate of the number of turbines and development footprint, it is considered to be a sufficiently conservative approach for the purposes of cumulative assessment. The combination that results in the maximum area of seabed permanently lost is based on a total of 420 turbines made up of 145 x 3.6 MW machines (seabed footprint including scour protection of 11,690 m^2 each) and 275 x 5 MW machines (seabed footprint including scour protection of 16,286 m^2 each) across the eastern and western areas. This equates to around 1.18% of the proposed Moray Firth Round 3 Zone development area. For cable installation it is assumed that 50% of the inter-array cable (maximum total length 482 km) is buried and that 50% requires mattresses or rock dumping that is 3 m wide, taking the total anticipated worst case losses from foundations and inter-array cable protection to

approximately 1.3% of the proposed Moray Firth Round 3 Zone development area across the eastern and western areas.

202. Further direct losses of seabed and seabed disturbance are anticipated from the installation of the OfTW and the Moray Firth Round 3 Zone OfTW. The worst case for installation of the OfTW involves a maximum of 0.44% of seabed lost to cable protection within the cable corridor, and similar amounts are assumed for the Moray Firth Round 3 Zone cable corridor. Further details are given in Section 22: Offshore Transmission Works Benthic Ecology.

203. The worst case scenario assumed to assess possible stepping stone effects for invasive species from the Moray Firth Round 3 Zone development involves the construction of 420 turbines.

204. There is no obvious worst case scenario for military activities, which are discussed further below.

205. Potential effects on benthos allied to physical processes, such as seabed disturbance, increased sediment deposition, or changes to sediment transport regimes, are based on the outputs of Section 9: Wind Farm Physical Processes and Geomorphology which considers the cumulative effects of the proposed Moray Firth Round 3 Zone development and the worst case scenarios used are therefore outlined in that Section of the ES.

10.9.7 PREDICTED EFFECTS

10.9.7.1 Construction effects

Disturbance of the Seabed

206. The degree of sediment disturbance associated with installation activities at the Moray Firth Round 3 Zone is not known in detail but is likely be broadly similar since the types of structure, cabling and construction methods being considered are all comparable. Thus the rig legs, anchors and cabling are likely to disturb a fraction of 1% of the seabed in the proposed Moray Firth Round 3 Zone development area each year over several years. Habitats and communities are broadly similar to those at the Wind Farm Site and so likely to recover over similar time scales of months to a few years.

207. The degree of sediment disturbance along the OfTW has already been assessed as being of minor significance due mainly to the potential for a small magnitude of effect on a community of medium importance; seapens and burrowing megafauna in circalittoral mud (albeit with a low density of seapens). Similar levels of disturbance are assumed for the Moray Firth Round 3 Zone transmission works.

208. The other main known proposed activities in the area (Polly Well and SHETL Hub) are far smaller and likely to result in very low levels of seabed disturbance other than very locally, and are not considered further here.

Assessment

209. The disturbance of very small areas of generally similar seabed communities from adjacent or more distant areas, and the disturbance of small areas of muddier

communities along the OfTW and Moray transmission cable corridors, does not directly affect the situation arising from the Wind Farm development and vice versa. The cumulative effects on communities of the Wind Farm Site are therefore considered to be unchanged from the effects of the Wind Farm alone i.e. effect of minor significance for the MedLumVen and MoeVen biotopes and of negligible significance for the PomB biotope and circalittoral fine sand biotope complex. Similarly, the cumulative effects on the communities along the OfTW are unchanged from those of the OfTW alone; based on an anticipated small magnitude of effect on a community of medium importance; seapens and burrowing megafauna in circalittoral mud, the effects are of minor significance. This is not a significant effect in terms of the EIA Regulations.

10.9.7.2 Sediment Deposition

210. As described in Section 9: Wind Farm Physical Processes and Geomorphology, deposition of fine sediments as a result of construction activities in the Moray Firth Round 3 Zone will, as with the Wind Farm , occur predominantly in areas to the south and south west of the relevant construction activities. This means that there will be relatively little overlap in the main areas of settlement from the two projects, and thus the Moray Firth Round 3 Zone will not add significantly to the amount of sediment settling in any one area as a result of the Wind Farm, which has been estimated at a maximum total of up to around 0.9 mm over the three year construction period, and more typically around 0.1 to 0.15 mm.

211. Similarly, deposition of fine sediments from the installation of the OfTW is anticipated to have only a negligible effect on the amount of sediments depositing within the wind farm area and other areas, including the areas identified as the main depositional areas for fine sediments from the construction of the Wind Farm. Deposition of fine sediments from the OfTW installation activities are anticipated to be less than 1 mm thick under most circumstances even quite locally to the activities. Thus the total amounts of fine sediments anticipated to be deposited in either the Wind Farm Site, or the main depositional areas for fine sediments identified to the south and south west of the Wind Farm, are not materially different to those already assessed as being deposited as a result of the construction of the Wind Farm.

212. Deposition of sand fractions will settle out very locally to the activity, typically within tens of metres, and therefore need not be considered here.

Assessment

213. The amount of additional fine sediments accumulating as a result of the Moray Firth Round 3 Zone construction activities and also the installation of the Beatrice OfTW will be negligible within the Wind Farm Site, and also negligible outside of the Wind Farm in the depositional areas that are anticipated to be affected by similar sediments from construction of the Wind Farm. The benthic invertebrate communities in these main depositional environments are known to inhabit sediments with some mud content already and not to be particularly sensitive to quite high levels of smothering or changes in suspended sediments. The cumulative

effects are therefore considered to be negligible in magnitude and of negligible significance for all benthic communities, whether along the OfTW, within the Wind Farm, or within the areas of fine sediment deposition to the south and south west of the wind farm. This effect is not significant in terms of the EIA Regulations.

Military Activity

214. During the EIA Scoping consultations the issue of potential cumulative effects of military activities on benthos was raised. The only known regular military activity with potential for effects in the same area as the Wind Farm development is the RAF bombing range off Tain in the Dornoch Firth. The MOD joint Warrior exercises, which are wide ranging exercises in UK waters, may include the Moray Firth area at times. Potential direct effects on benthos of the bombing activity, if any, are not known in detail but are likely to be extremely localised, and affecting seabed communities that are both remote from, and probably quite different to, those at the Wind Farm Site. Noises from loud explosions may occur from both activities and may have the potential for localised short term disturbance effects, but noise during construction of the Wind Farm (and operational noise, which is at a far lower level) has already been assessed as being not significant for the Wind Farm. There are, therefore, no known military activities with potential for detectable cumulative effects on the benthos in the vicinity of the Wind Farm. Cumulative effects are thus considered to be of negligible significance. This effect is not significant in terms of the EIA Regulations.

10.9.7.3 Operational effects

Loss of Habitat

215. Using the worst case scenarios outlined above it can be estimated from the data provided by Moray Firth Round 3 Zone that a maximum of approximately 1.3% of the seabed area in the Moray Firth Round 3 Zone development area will be lost as a result of placement of foundations and scour protection (including inter-array cable protection). This is a smaller percentage loss than the 2.9% that has been estimated for the Wind Farm, although the Moray Firth Round 3 Zone is much larger than the Wind Farm Site.

216. Seabed losses from the proposed Polly Well at Beatrice and the more distant SHETL hub project will be much smaller in scale, and probably comparable at worst to a single turbine from either of the wind farm developments. These potential losses are not considered to make any material difference to the conclusions of this cumulative assessment.

217. The seabed communities have been identified as being generally very similar over the Wind Farm Site and the Moray Firth Round 3 Zone (eastern areas), except that the potentially important MoeVen biotope (a possible PMF) is absent from the Moray Firth Round 3 Zone. As with the Wind Farm assessment, given the large areas covered by most of the biotopes or biotope complexes, it is reasonable to infer that 1.3% represents the likely percentage loss for each, with the exception of the PomB biotope which could theoretically be more heavily affected.

218. The seabed communities on the OfTW are different to those in the wind farm sites except very close to the Wind Farm and very close to the shore, being in the main much muddier and therefore with different communities. The estimated loss of approximately 0.44% of benthic habitat within the cable corridor that is anticipated as a result of the installation of the OfTW and associated protection (including cumulatively with the Moray Firth transmission cables, where similar low losses are anticipated) do not, therefore, materially affect the assessment.

Assessment

219. The loss of small areas of generally similar seabed communities from adjacent areas and of even smaller areas of mainly muddy or inshore sandy and cobble communities from areas associated with the OfTW for the Wind Farm and Moray Firth Round 3 OfTW do not materially affect the situation arising from the Wind Farm Site, nor vice versa. The cumulative effects are therefore considered to be as assessed for the wind farm and OfTW individually.

220. The MoeVen biotope is conservatively considered to be of high importance, but up to 2.9% loss represents a small magnitude of effect, resulting in a permanent negative effect of moderate significance.

221. The MedLumVen biotope and Circalittoral fine sand biotope complex are considered to be of medium importance. Given that 2.9% loss represents a small magnitude of effect this results in a permanent negative effect of minor significance.

222. The PomB biotope is very limited in extent, with only a single well identified area of 0.021 km^2 within the Wind Farm Site. There is, therefore, the theoretical possibility that all, or virtually all, of the known PomB biotope could be permanently lost if a gravity based OSP or turbine coincides directly with the area. However, it should be noted that the scour protection around all of the foundation supports may comprise loose rocks that are likely to support populations somewhat similar in nature to those already existing on the stones in this biotope, but will be much more extensive. Moreover, barnacles and encrusting tubeworms, along with other fauna occurring in this biotope, are known to be amongst the most dominant fauna encrusting hard surfaces in the Moray Firth, so that similar, though more stable and hence probably richer, communities are likely to develop if mattresses are used. It is therefore assessed that in the context of the Study Area as a whole the overall magnitude of effect is small, and not substantially affected by the OfTW, Moray Firth Round 3, or other developments, and given the low importance of the biotope this results in a permanent negative effect of minor significance. This effect is not significant in terms of the EIA Regulations.

223. Along the OfTW, due to the very small area affected, even in the worst case scenario, the negligible magnitude of effect and the low-medium importance of the receptors the significance of this effect is considered to be of negligible significance as assessed in Section 22: Offshore Transmission Works Benthic Ecology. This effect is not significant in terms of the EIA Regulations.

10.9.7.4 Changes to water movement

224. Section 9: Wind Farm Physical Processes and Geomorphology predicts changes to both wave action and currents as a result of the development of the Wind Farm. Section 9: Wind Farm Physical Processes and Geomorphology also predicts that cumulative effects with the Moray Firth Round 3 Zone will occur on maximum wave height and to a much lesser extent on tidal currents.

225. Maximum wave height within the Wind Farm (considering the Wind Farm development alone) is predicted to be reduced by up to 20%, but this maximum effect is limited to a very small area (length scale of the order of 1 km) of the combined wind farms. Half of the Wind Farm Site area is expected to show a much smaller reduction in maximum wave heights of less than 10%, and one quarter of the site will experience reductions in maximum wave heights of less than 5%. Smaller waves are expected to be affected to a much lesser degree. Beyond the Wind Farm, the reduction in maximum wave height experienced will change in a non-linear fashion, i.e. recovering quickly over small distances but with some residual effects over larger distances. Wave period and direction are considered not to be measurably affected.

226. Cumulative effects on current speeds are also predicted, but these relate only to phasing of the currents, with the current speed at neap tide being unaffected by the developments, and maximum current speed at spring tides being reduced by 0.01 ms^{-1} (roughly 2% of the baseline condition) both by the Wind Farm alone, and cumulatively by the Wind Farm and the Moray Firth Round 3 Zone.

227. Filter feeding members of the seabed community, which are probably slightly more prevalent in the PomB and MedLumVen biotopes than the other biotopes, are dependent upon water movement in order to provide a supply of food. However, the anticipated changes are extremely unlikely to make any meaningful difference in this regard.

228. Potential reduction in the degree to which sediments are mobilised might also be expected to influence seabed communities. In this regard wave period, rather than simply wave height, might also be an important factor, since longer waves are more likely to penetrate to the seabed. Based on combined changes to waves and currents, Section 9: Wind Farm Physical Processes and Geomorphology concludes that there will be only minor changes in the textural properties of the seabed sediments, and that any changes to seabed sediment processes, such as mobilisation and transport of sediments, will be small and less than the potential for natural variability. Effects such as reduced physical scouring by sediment particles, marginally increased feeding opportunities for filter feeding members of the community, due to lack of clogging by suspended sediments during periods of high water movement, or marginally reduced feeding efficiency due to lower levels of suspended detrital food particles, may theoretically occur, but given the very low levels of changes anticipated are extremely unlikely to be sufficient to cause detectable changes to the communities.

229. Of the identified seabed communities the most sensitive receptor might be expected to be the PomB biotope, the nature of which is heavily influenced by the effects of water movement on the stony substrate – although this probably relates more to the rolling around on the seabed of pebbles and stones, than to scouring by smaller particles. This action prevents the establishment and growth of many organisms, so that the community is dominated by scour tolerant fauna such as calcareous tubeworms, barnacles and certain bryozoan species. The small areas of PomB found within the Wind Farm were found not to be perfect matches with this biotope, being slightly richer in places, suggesting scouring is not particularly severe. In the event that these small anticipated changes reduce overall scouring effects further there might conceivably, therefore, be some further very small trend towards enrichment of this biotope in numbers of species and biomass, but based on the anticipated level of changes this seems unlikely to be a measurable effect.

Assessment

230. The anticipated changes to both current and wave regimes, and their effects on seabed sediments, are mostly small, and not anticipated to be outwith the range of natural variability on annual or decadal timescales even within the Wind Farm Site. At the regional scale, such as at coastal areas of the Moray Firth, they are unlikely to be even measurable in practise in most cases. They are not, therefore, expected to cause detectable changes in any of the seabed communities present either within the Wind Farm Site, or elsewhere in the Moray Firth.

231. Any effect on seabed communities of changes to water movement by currents and waves is therefore considered to be of negligible magnitude and hence of negligible significance, as was assessed for the Wind Farm alone. This effect is not significant in terms of the EIA Regulations.

Possible Stepping Stone Effect for Invasive Species

232. There is no published or anecdotal evidence that the installation of large numbers of offshore platforms and pipelines in the North Sea in recent decades has led to a spread of invasive species. The density of structures within extensive wind farm areas such as the Beatrice Offshore Wind Farm will be greater, and clearly the existence of both the Beatrice Offshore Wind Farm and the Moray Firth Round 3 Zone together would represent a larger aggregation of structures.

233. The effect of increasing the number of hard substrate areas in the form of turbine foundations and supports may theoretically increase the rate of spread of invasive species, but this is presently impossible to confirm or quantify. Given the distance offshore, the longstanding existence of numerous artificial substrates associated with the offshore oil and gas industry both in the Moray Firth and further offshore, and the existence already of frequent, even if small and scattered, natural hard substrates in the form of cobble and boulders, in both the Wind Farm and the Moray Firth Round 3 Zone, it appears very unlikely to make a difference to whether an invasive species reaches one part of Scottish waters from another.

Assessment

234. The existence of the 280 structures of the Wind Farm together with the 420 or so likely structures of the Moray Firth Round 3 Zone will form an environment that theoretically may increase the rate of spread of some invasive species through Scottish Water slightly, but it seems very unlikely that any spread will be noticeably more effective, or more rapid, in the combined presence of the two adjacent wind farms than in the presence of the Wind Farm alone. This potential effect is therefore considered to be at most of minor significance, as was assessed for the Wind Farm alone. This effect is not significant in terms of the EIA Regulations.

10.9.8 MITIGATION MEASURES (POST CUMULATIVE ASSESSMENT)

235. There are no practical mitigation measures that can be put in place to reduce any of the anticipated effects described in Section 10.9 above. The most significant effects result from direct loss of sandy seabed habitat supporting a MoeVen biotope as a result of the emplacement of gravity based foundations and associated scour protection, along with rock or concrete based cable protection. There is no feasible option for mitigating these losses.

10.9.8.1 Residual Effects (Post Cumulative Assessment)

236. Residual effects are therefore the same as the effects described in Section 10.9.7 above.

10.9.9 SUMMARY

237. Table 10.6 provides a summary of potential cumulative effects. No significant cumulative effects on benthic invertebrates are anticipated.

Table 10.6 Summary of Potential Cumulative or In-combination Effects on Benthic Invertebrate Receptors

Effect	Predicted Significance	Mitigation Proposed	Residual Effect Significance
Wind Farm: Construction			
Disturbance to seabed	Minor significance for the MedLumVen and MoeVen biotopes, and for communities along the OFTW Negligible significance for the PomB biotope and circalittoral fine sand biotope complex	No	minor significance for the MedLumVen and MoeVen biotopes, and for communities along the OFTW Negligible significance for the PomB biotope and circalittoral fine sand biotope complex
Sediment deposition	Negligible significance		Negligible significance
Military activities	Negligible significance for all benthic communities	No	Negligible significance
Wind Farm: Operational phase			

Effect	Predicted Significance	Mitigation Proposed	Residual Effect Significance
Loss of habitat	Moderate significance for MoeVen biotope Minor significance for MedLumVen biotope and circalittoral fine sand biotope complex Minor significance for PomB biotope	No	Moderate significance for MoeVen biotope Minor significance for MedLumVen biotope and circalittoral fine sand biotope complex Minor significance for PomB biotope
Changes to water movement	Negligible significance		Negligible significance
Possible stepping stone effect for invasive species	Minor significance.	No	Minor significance

10.10 *STATEMENT OF* SIGNIFICANCE

238. Permanent losses of up to 2.9% of the seabed habitat within the Wind Farm area to gravity based foundations (including associated scour protection), along with cable protection in the form of concrete mattressing or rock dump, represent an effect of moderate significance where they occur on the MoeVen biotope, a seabed community that may represent an important feeding resource and that is considered a possible PMF by SNH. There is no feasible mitigation for these losses.

239. Seabed losses that occur on other seabed communities within the Wind Farm area represent non- significant effects.

240. Other operational effects of the Wind Farm that were assessed were found not to have significant effects. These were: scour effects; changes to water movement; creation of new habitat; possible stepping stone effect aiding the spread of invasive species; operational noise; EMF effects; and changes in fishing activity.

241. Construction effects that were assessed were found not to have significant effects. These were: sediment deposition both within and outside of the wind farm; noise during construction; and release of chemicals).

242. Decommissioning effects that were assessed were found not to have significant effects. These were: noise and vibration, and disturbance of the seabed.

10.10.1 CUMULATIVE EFFECTS

243. There are no cumulative effects that make any difference to the significance of any of the above effects of the Beatrice Offshore Wind Farm.

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