European Offshore Wind Deployment Centre

Environmental Statement

Chapter 8: Coastal Processes

A project part-funded by the European Union under the European Economic Plan for Recovery in the field of Energy

8 COASTAL PROCESSES

8.1 Introduction

1 ABPmer was commissioned by the Applicant to undertake an assessment on coastal processes. This section defines the baseline (existing) coastal processes within the study area and presents the potential impacts of the development relative to this baseline regime. In order to assess the potential effects of EOWDC relative to the baseline (existing) coastal environment, a combination of qualitative assessment of site data, empirical evaluation and detailed numerical modelling has been used to establish the potential magnitude and significance of the predicted changes. These effects have been assessed using the 'worst case' characteristics of the proposed development, as provided by the project. Considerations of the proposed effects upon the tide and wave regimes have been made and the subsequent impacts upon a series of receptors determined, including the offshore seabed morphology and littoral sediment regime. Comment has also been made to address relevant concerns raised by consultees, as fully presented in Appendix 4.2.

2 The following technical reports support this chapter and can be found as:

- European Offshore Wind Deployment Centre: Coastal Processes Baseline Report (Appendix 8.1) and
- European Offshore Wind Deployment Centre: Coastal Processes Assessment Report (Appendix 8.2)

8.1.1 Methodology Consultation

3 The scope of present considerations undertaken for coastal processes considers the specific issues raised through project consultation in combination with the generic project requirements, as detailed in present guidance.

4 A series of coastal process topics were raised as a result of the consultation of the Environmental Impact Assessment (EIA) Scoping Report (Appendix 4.1). Responses from four organisations were provided which have concerns relevant to coastal process issues. The full list of organisations whom submitted responses relevant to coastal processes at the current development are:

- Aberdeen Harbour Board Scottish Natural Heritage (SNH) Scottish Environmental Protection Agency (SEPA) and
- Marine Scotland

8.1.2 Key Guidance Documents

5 Guidance on the generic requirements, including spatial and temporal scales for coastal process studies is provided in six main documents:

- 'Offshore wind farms: guidance note for Environmental Impact Assessment in respect of Food and Environmental Protection Act (FEPA) and Coast Protection Act (CPA) requirements: Version 2' (Department for

Environment, Food and Rural Affairs (Defra), Centre for Environment, Fisheries and Aquaculture Science (Cefas) and Department for Transport (DfT), 2004)
- ‘Guidance on Environmental Impact Assessment in Relation to Dredging Applications’ (Office of the Deputy Prime Minister, 2001);
- ‘Nature Conservation Guidance on Offshore Wind Farm Development’ (Defra, 2005)
- ‘Marine Renewable Energy and the Natural Heritage: An Overview and Policy Statement’ (Scottish Natural Heritage, 2003)
- ‘Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment’ (COWRIE, 2009); and
- Consenting, EIA and HRA Guidance for Marine Renewable Energy Deployments in Scotland’ (EMEC & Xodus AURORA, 2010)

8.1.3 Data Information and Sources

6 The main data and information sources are summarised as follows, for further details on these data sources the reader is referred to Appendix 8.1.

- Five months of metocean survey between 12th September and 13th February 2008 (Emu, 2008a)
- Geophysical surveys covering the original study area (Emu, 2008b) and the EOWDC site (Osiris, 2010)
- Geotechnical review of existing borehole information (Setech, 2009)
- Grab samples covering the previous site collected by the Fisheries Research Services (FRS) (Titan, 2008), covering the EOWDC site collected in 2010 by the Centre for Marine and Coastal Studies (CMACS Ltd) and covering the intertidal are adjacent to the EOWDC (Appendix 8.1) Beach profiles collected by ABPmer(Appendix 8.1); and
- Water level data collected in Aberdeen Harbour by the British Oceanographic Data Centre’s (BODC) National Tide and Sea Level Facility (NTSLF) between 1980 and 2005

7 Reports from other previous work have also been compiled that describe various aspects of the study area, the principal studies are summarised below:

- Aberdeen Bay Coastal Protection Study (Halcrow Crouch Ltd, 1999)
- Coastal Cells in Scotland, Cell 2 (HR Wallingford, 2000)
- Coastal processes and management of Scottish estuaries, The Dee, Don and Ythan Estuaries (Stapleton and Pethick, 1996)
- Beaches of Northeast Scotland (Ritchie et al, 1977); and
- SEA 5 (DTI, 2005)

8.2 Baseline Assessment

8 The baseline, or pre-construction, phase considers the coastal processes prior to any wind farm works. The investigation of this phase is relevant as it provides a condition to which the coastal processes during all other phases can be compared. It should be noted that any changes to the coastal processes within the lifetime of the array due to natural variability will also be compared to this phase.

9 The pre-construction phase forms the baseline which has been discussed within the preceding report (Appendix 8.1).The proposed development is located between 2 and 4.5 km offshore in water depths ranging from 10 to 30 mCD (below Chart Datum). The seabed has a gentle gradient from the offshore to the shoreline, which increases in a shoreward direction. There is no evidence of large-scale bedform features within the proposed EOWDC site (Emu, 2008a; Osiris, 2010). In the shallower areas west of the site some seabed features are present including wave-induced ripples, areas of exposed glacial material and a shore parallel ridge (Figure 8.1).

10 Tidal range within the proposed site is 3.4 m and 1.7 m under mean spring and neap tidal conditions, respectively. Peak tidal currents have been measured at less than 1.1 m/s (near-surface) within the proposed EOWDC site, decreasing in magnitude towards the shore. Average near-bed and surface speeds recorded are approximately 0.22 m/s and 0.33 m/s, respectively. The peak flow occurs at approximately the times of high and low water, with slack water occurring mid-tide. The tidal axis is orientated approximately shore parallel, flooding towards the south-southwest and ebbing towards the north-northeast (Figure 8.2). Flood currents are slightly stronger than those of the ebb tide. The rectilinear nature of the tide increases from near-surface to the mid-water column.

11 The most frequently occurring waves within the proposed EOWDC site (based on observations made during a 5 month winter survey) are between 0.5 and 1.0 m significant wave height and originate from the southeast. The largest wave heights recorded within this period are of the order of 5.5 m and originate from the east (Figure 8.3). Further offshore, due to the absence of coastal sheltering, northerly wave directions predominate.

12 Analysis of the exposure conditions (tides, waves) in view of the surficial seabed sediments experienced within the array has been undertaken to assess the potential mobility of the seabed. Within the proposed EOWDC site, the seabed material has been observed to be predominantly sand (grain diameter 150 micrometre (µm)) with some mud and gravel in places. The presence of different size fractions acts to provide some armouring to the seabed. It is shown that both tidal and wave processes influence sediment mobility, with tides having a greater influence in the offshore. Analysis of tidal currents measured near the seabed shows that tidal asymmetry within the lower water column results in a net northerly transport of the typically present sand sized sediment. However, the seabed sediment transport regime within the wind farm boundary is not particularly active with respect to these size fractions.

13 The net direction of longshore transport has been shown to be in a northerly direction and under the control of waves (the more frequent waves originate from the southeast). This is evidenced by the rivers that have typically been deflected to the north due to the sediment deposition at the mouths. However, the southerly orientation of a spit across the mouth of the River Ythan at the northerly end of the bay indicates the potential for net southerly directed littoral transport in this part of the bay. Wave refraction causes some southerly directed transport in the far southern part of the bay adjacent to the mouth of the Dee. The rate of littoral transport decreases towards the north of Aberdeen Bay as a consequence of its changing alignment, an observation which is supported by the fining of beach sediment towards the north.

However, under extreme storm events, the potential alongshore transport potential is much greater in the north of the Bay than the south.

14 Aberdeen Bay is characterised by dune backed sandy beaches. Some aeolian exchange of dry sediment occurs between the dunes and the beach, with the beach supplying sediment to the dunes under ‘normal’ wind and wave activity. Some sediment may also be released back onto the beach during storm events through wind erosion and wave erosion in conjunction with high water levels. The overall erosion of the beach indicates that current sediment sources are not adequate to maintain the beach profile. This is probably due to the limited transfer of sediment from offshore.

8.3 Impact Assessment

8.3.1 Impact Assessment Methodology

15 A combination of qualitative assessment of site data, empirical evaluation and detailed numerical modelling has been used to establish the potential magnitude and significance of the predicted changes. These effects have been assessed using the ‘worst-case’ characteristics of the proposed development, as provided by the project. These are presented in Table 8.1.

TABLE 8.1 Scenarios Assessed for Coastal Processes	
Potential Impact	**Likely scenario assessed**
Phase: Construction and decommissioning	
Increase in suspended sediment concentrations as a result of installation / removal activities	Foundation Installation: 2,100 m^3 of sediment disturbed for the installation of each monopile foundation. Total of 11 structures with an installation period of 5 days per wind turbine/foundation. Monopile with diameter of 8.5 m and maximum burial depth of 37 m. Sediment disturbed includes combination of mud and fine sand, released in-situ next to structures. Cable Installation: 405,000 m^3 of sediment disturbed for 26 km of cable installation using mass excavation methods. Installed at rate of 500 m/hr and 5 m/hr in water depths greater and less than 2 m, respectively. Maximum depth and width of trench 3 m and 10.38 m, respectively. Sediment disturbed includes combination of mud and medium sands.
Phase: Operational	
Changes to processes acting within Aberdeen Bay. Including: (i) Changes to the tidal and wave regimes as a result of the presence of the turbine foundations. (ii) Changes to the seabed form receptor	Array consisting of 11 Gravity Base Structures with base diameter 40 m, tapering to 6.5 m at 10 m below Lowest Astronomical Tide (LAT). Cumulative effect allows for the addition of Ocean Laboratory located approximately 300 m from the nearest turbine. Represented as a Gravity Base Structure with dimensions as per the array structures.
Introduction of seabed scour as a result of the presence of construction equipment and turbine foundations.	Includes monopile, jacket, tripod, gravity base and suction caisson/bucket structures. Cumulative effect allows for the addition of Ocean Laboratory located approximately 300 m from the nearest wind turbine. Represented as a Gravity Base Structure with dimensions as per the array structures.
Changes to processes acting to maintain the Aberdeen Bay coastline	Array consisting of 11 Gravity Base Structures with base diameter 40 m, tapering to 6.5 m at 10 m below LAT.

16 Numerical models from the Danish Hydraulics Institute (DHI) have been applied to assess the effects of the potential development upon the existing coastal processes within the site and the wider sub-tidal area. Another numerical model ‘XBeach’ has also been used to determine potential changes to the beach morphology and nearshore (littoral) regime. The potential for localised scour around the turbine foundations has been assessed using empirical methods on the basis of foundation design information and the baseline understanding of tidal, wave and sedimentary environments.

17 When assigning significance to an impact, the methodology can be summarised as follows:

- the magnitude of the effect (Table 8.2) is determined based on a combination of the spatial extent, the duration and the scale of the effect; and

- the sensitivity of the receptor is determined by considering the recoverability and the importance of the receptor and assigning a value of very high, high, medium or low

18 Using a combination of these criteria, impacts are assigned an impact significance rating of major, moderate, minor or negligible (Table 8.3).

19 This approach to impact assessment is based on matrix as supplied by the Applicant (See Table 4.2). It is important to note that this approach assumes that all impacts are adverse or detrimental in nature, however, some impacts might actually have beneficial implications for the receptor concerned.

TABLE 8.2
Outline Criteria for Assessing the Magnitude of the Effect (adapted from AOWFL, 2010a)

Rating	Spatial extent criteria	Duration criteria	Scale criteria
Very High	National/ International	>10 years	Very high level of change compared to background
High	Regional	5 – 10 years	High level of change compared to background
Medium	Local (<5km)	1 – 5 years	Medium level of change compared to background
Low	Site specific	<1 year	Low level of change compared to background
Negligible	Restricted to the immediate vicinity	Negligible	Negligible level of change compared to background

TABLE 8.3
Matrix Used to Assign Level of Significance (Adapted from AOWFL, 2010a)

Magnitude of effect (based on combination of criteria in Table 1)	Sensitivity of Receptor			
	Very High	High	Medium	Low
Very High	Major	Major	Major	Moderate
High	Major	Major	Moderate	Minor
Medium	Major	Moderate	Moderate	Minor
Low	Moderate	Minor	Minor	Negligible
Negligible	Minor	Negligible	Negligible	Negligible

8.3.2 Potential Impacts: Construction and Decommissioning Phases

8.3.2.1 Changes to Processes Acting within Aberdeen Bay as a Result of the Presence of Construction Equipment

20 The temporary presence of construction equipment is not considered to affect the tide and wave regimes. Consequently any impacts upon seabed morphology would be small in magnitude, temporary and localised.

21 In terms of coastal processes, the offshore seabed form is considered to be of low importance as it does not have any designated features and is considered to be of medium recoverability (due to the weak tidal conditions limiting the frequency and magnitude of sediment mobility).

22 The potential impact has been assessed of negligible magnitude, low sensitivity and therefore of negligible significance.

8.3.2.2 Seabed Changes as a Result of the Presence of Construction Equipment and Wind Turbine Foundations eg Scour

23 Construction vessels may use jack-up legs or a number of large anchors to hold station during construction operations. These (in conjunction with an additional limited amount of sediment scouring) may leave indentations on the seabed, post construction. The maximum footprint of the construction equipment would result from the use of one 6-legged jack and one 6-legged barge per wind turbine installation, with a total footprint per wind turbine of 4,200 m^2. This amounts to 0.021 % of the EOWDC lease area per wind turbine location.

24 The relative seabed immobility may mean that the indentations persist over the short-term. However, due to the small area of the potential indentations, this impact is considered to be of negligible magnitude.

25 The potential impact has been assessed of negligible magnitude, low sensitivity and therefore of negligible significance.

8.3.2.3 Potential Impact: Increase in suspended sediment concentrations as a result of installation / removal activities

26 During the installation of the foundation structures and cables, there is the potential for sediment re-suspension and subsequent dispersal. The scoping exercise identified sensitive receptors within nearby European designated sites and also concerns regarding sediment deposition within Aberdeen Harbour.

27 Sediment re-suspension and dispersal has been considered using numerical modelling techniques. Sediment resuspension rates vary between operations and are dependent upon the duration of works and the sediment volume released. The scenarios tested are provided in Table 8.1.

28 The localised resuspension of material by construction equipment during both foundation installation and cable burial leads to sediment dispersal in suspension both within the site and the wider area. Whilst sediment is being actively released, material in suspension initially accumulates within Aberdeen Bay. Once installation activities cease, the remaining suspended sediment is more widely dispersed, reverting to ambient background levels.

29 Results indicate that suspended sediment concentration levels are typically <8 mg/l and <40 mg/l, above natural background levels, for the foundation and cable works, respectively. Localised maximum concentrations of 100 mg/l and 90 mg/l, above natural background levels, also occur for the foundation and cable works, respectively but these are shown to be short-lived. Measured suspended sediment concentrations within the EOWDC array are shown to a maximum of 43 mg/l (Emu, 2008). The results are illustrated in Figures 8.4 and 8.5. Concentrations are given as depth-averaged values and as such may be slightly higher towards the bed and lower towards the water surface. Cable burial using mass excavation tools is

shown to produce a greater increase in suspended sediment concentration levels relative to the foundation installation works.

30 Due to the fine nature of the sediments suspended by the construction activities (Table 8.1), there was found to be little potential for measurable deposition of material within Aberdeen Bay and so upon sensitive receptors. It was found to be more likely that the material would become widely dispersed in the offshore environment.

31 A very small proportion of the total volume of sediments suspended may be entrained into Aberdeen Harbour by normal tidal exchange. The largest total volume of silt sized sediment potentially resuspended by the installation of foundations would result from 11 gravity bases and is equivalent to a maximum of 0.2 m unconsolidated sediment thickness, if deposited directly and evenly over an area equivalent to that of Aberdeen Harbour. Naturally occurring processes of advection, dispersion and sediment settlement in the coastal environment make it highly unlikely that any significant proportion of the total sediment volume disturbed would actually enter and subsequently settle inside the harbour. It is also unlikely that all foundations would be gravity bases, given the nature of the EOWDC development, further reducing the total sediment volume and the potential for its accumulation elsewhere.

32 A very small proportion of the total volume of sediments suspended may be entrained into Aberdeen Harbour by normal tidal exchange and as a consequence of the one-off short-term (52 hour) cable installation activity. It is, however, considered that, given the short-term duration of the installation works combined with the naturally occurring processes of advection, dispersion and sediment settlement in the coastal environment, it is highly unlikely that any significant proportion of the total sediment volume disturbed would actually enter and subsequently settle inside the harbour. Should the mass excavator tool not be used, the total sediment volume would be further reduced as would the potential for its accumulation elsewhere.

33 The potential impact within the Aberdeen Harbour has been assessed of low magnitude, medium sensitivity and therefore of minor significance.

34 Localised, temporary increases in sediment concentrations are shown to occur into areas designated for conservation at a European level. Some of the designations are for the onshore dune and coastal habitat features which would not be affected by temporary increases in marine suspended sediment levels. The marine exposed area affected by localised changes in suspended sediment concentration changes is along the Buchan Ness to Collieston coast. The temporary, localised concentration elevations above natural background levels, which may occur here are less than 8 mg/l.

35 The potential impact within designated sites has been assessed of low magnitude, high sensitivity and therefore of minor significance.

8.3.3 Potential Impacts: Operational Phase

8.3.3.1 Changes to Processes acting within Aberdeen Bay

36 Sediment transport within Aberdeen Bay is controlled by both the tidal and wave regimes, with the latter shown to exert a sizeable, relative, contribution

to the mobilisation of seabed sediments. The wave regime is shown to have a predominant influence upon the littoral sediment transport (Section 8.3.3.3). The absence of significantly large bedforms within the offshore area is probably due to a combination of weak tidal currents not creating bedforms and wave events further flattening the seabed during storm events.

37 The analyses of impacts on both the tidal and wave regime have demonstrated no significant impacts; whilst tidal currents may be slightly modified (<0.05 m/s) this does not occur at the time of peak flow and so the naturally occurring range of speeds remains unaffected (Figure 8.6). With respect to water levels, the analysis showed no measurable increases or decreases in this parameter. Significant wave heights (Hs) are reduced in the lee of the wind turbines by a small amount (< 0.1 m) for frequent, low energy wave conditions. For the most frequently occurring wave conditions (Hs 0.5 to 1.0 m from the south-east), wave height changes of less than 0.05 m are more common (Figure 8.7). As expected, it is under the larger wave heights that the largest absolute differences and spatial extents of effect are observed. The largest reported reduction in wave height is localised to within the immediate lee of individual wind turbines and is markedly less elsewhere (< 0.01 m at the shoreline) (Figure 8.7).

38 The combined changes to the tidal and wave regimes are not expected to have any significant impacts on the offshore sediment regime.

39 In terms of coastal processes, the offshore seabed form is considered to be of low importance as it does not have any designated features and is of medium recoverability due to the weak tidal conditions.

40 The potential impact has been assessed of negligible magnitude, low sensitivity and therefore of negligible significance.

8.3.3.2 Introduction of seabed scour as a result of the presence of turbine foundations

41 Currents and wave induced flow would interact with the foundations, resulting in accelerated flow and elevated turbulence at the seabed adjacent to the structure's edge. The resulting increase in bed shear stress and potential for sediment mobilisation results in sediment scour whereby a depression is formed in the seabed around the base of the foundation. The rate of scour development is generally rapid enough for the equilibrium scour depth (for the given flow conditions in unconsolidated non-cohesive sediments) to be achieved over a period of a few tides. Using empirical relationships, the equilibrium scour depth for each foundation type resulting from a combination of both waves and currents was calculated and summarised in Table 8.4.

TABLE 8.4
Summary of Scour Characteristics Assuming a Uniform Erodible Sediment

Parameter	Foundation Option				
	Monopile	**Jacket***	**Tripod**	**Gravity Base**	**Suction Caisson**
Equilibrium Scour Depth (m)					
Steady Current	11.05	3.25	3.25	7.2	3.6
Waves	Negligible	0.5	2.2	1.6	0.8
Waves and current	≤ 11.05	≤ 3.25	≤ 3.25	18	9
Group Scour	N/A	~1	~1	N/A	N/A
Scour Extent					
Scour extent from foundation ** (m)	18	5	5	12	6
Scour footprint ** (m^2)	1,445	1,472	1,101	1,865	466
Foundation footprint (m^2)	57	20	15	1,257	314
Scour Volume**					
Scour volume (m^3)	6,228	749	884	6,214	777

* Bed prep volume negligible if corner piles are inserted without drilling
** Extent and area excluding the foundation. Values based upon the scour depth for steady currents. Footprint and volume values per foundation.
Whilst these calculations assume an uniform erodible sediment, the presence of the Wee Bankie formation at, approximately, 10m to 20m below the seabed is likely to restrict the scour depth.

42 In terms of scour depth, the gravity base structure has the potential to cause the largest impact due to its large dimensions. However, the estimated maximum depth (18 m) is unlikely to be attained due to the potential constraints arising from the sub-surface geology with a till surface (termed the Wee Bankie Formation) at, approximately, 10 m to 20 m below the present seabed level (Osiris, 2010). This layer is described as a soft to very stiff clay with occasional sand and gravel lenses (SEtech, 2009). Group scour is expected to be minimal and the risk for global scour is considered to be negligible.

43 The extent of scour from the edge of each foundation is also shown in Table 8.4. This is calculated assuming the profile of the scour pit is an inverted cone with slopes at the angle of repose for sand (32°). The footprint or area of the scour pit (excluding the foundation footprint) is also provided, together with the footprint of the foundation for comparison. The gravity base foundation would result in the greatest total scour footprint; the suction caisson would produce the least. Table 8.5 summarises the total foundation and scour footprints and as a proportion of the lease area.

44 The time required for the majority of scour pit development around each foundation within the EOWDC is estimated to be within the order of 6 to 12 hours (under flow conditions sufficient to induce scour). This makes the assumption of a mobile uniform non-cohesive sediment substrate. Symmetrical scour would only develop following exposure to both flood and ebb tidal directions. Waves do not typically cause rapid initial scour directly, but can increase the rate of initial scour development.

45 The potential impact has been assessed of medium magnitude, low sensitivity and therefore of minor significance.

TABLE 8.5
Summary of Predicted Scour as a Proportion of the Lease Area

Parameter	**Foundation Option**				
	Monopile	**Jacket***	**Tripod**	**Gravity Base**	**Suction Caisson**
Number of devices	11	11	11	11	11
Seabed footprint of all devices (m^2)	624	216	162	13,823	3,456
Proportion of total site area (%)	0.003	0.001	0.001	0.069	0.017
Seabed footprint of all devices + scour (m^2)	16,625	7,354	12,269	34,339	8,585
Proportion of total site area (%)	0.083	0.037	0.061	0.172	0.043

8.3.3.3 Changes to Processes Acting to Maintain the Aberdeen Bay Coastline

46 The main control on the nearshore sediment transport (littoral) regime is wave processes and therefore the impact assessment is focussed upon this aspect.

47 Potential impacts on the littoral regime were assessed for both frequent, low energy and infrequent, high energy wave events and directions experienced within the study area. Therefore the climate assessed was that resulting from winds (and waves) coming from, at the offshore boundary northeast (60 °N); east (90 °N); southeast (120 °N); and south-southeast (150 °N) at speeds of 8, 12 or 16 m/s. These wave conditions were suitably transformed in the model by processes of refraction and shoaling across the study area and the nearshore bathymetry, simulating naturally occurring modification to wave height, period and direction in the area. The relative difference in the morphological response of 3 km of shoreline in the developments lee was calculated by comparing pre- and post-construction scenarios.

48 'Natural' cross-shore profile changes occur in response to different (naturally occurring) wave conditions. The beach response is also spatially variable and ultimately dependent upon the initial local morphology. As would be expected, the magnitude of the beach response increases with increasing wave height. Absolute beach elevation changes are less than 0.2 m when significant wave height (Hs) is less than 1 m; conversely, to induce a beach elevation change greater than 0.5 m requires a wave height, Hs of larger than 3 m, with an associated peak wave period (Tp) greater than 10 s. For context, more than 45 % of wave heights recorded by the project specific, 5 month, metocean campaign (EMU, 2008) are less than 1 m and the 10 in 1 year return period wave condition, as derived from a longer (30 years) data set, at the AWAC site is 2.1 m (Hs) and 7.3 s (Tp) (Appendix 8.1). The metocean survey therefore shows that the conditions required to result in a +0.5 m beach profile change can be considered as infrequent events.

49 The additional presence of the EOWDC is shown to result in small additional changes (+0.05 m) under everyday events and slightly larger (+0.2 m) under the less frequent events (Figure 8.8). The development has been shown to slightly reduce significant wave height at the adjacent shoreline and so is most likely to result in a reduced variability in beach elevations. Changes to the frequency or magnitude of beach level change attributable to the EOWDC are within the range of those occurring naturally and as such would likely be indistinguishable from the natural variability. Therefore, the changes that may be induced by the EOWDC are considered to be of low magnitude.

50 The potential impact has been assessed of low magnitude, medium sensitivity and therefore of minor significance.

8.3.4 Potential Impacts: Cumulative Effects

8.3.4.1 Changes to Processes Acting within Aberdeen Bay as a Result of the Cumulative Presence of Wind Turbine Foundations and the Ocean Laboratory

51 As with the wind farm array, the presence of the Ocean Laboratory has the potential to impact on the local tidal and wave regimes as they interact with the structure. Any changes to these regimes may have a resultant impact on the sediment regime (both offshore and coastal) and therefore requires consideration.

52 A comparison of Figures 8.6 and 8.9 indicates that the cumulative impacts of the Ocean Laboratory and the EOWDC does not induce a greater magnitude of change to the tidal regime beyond that predicted by the EOWDC alone. Flow speed changes are predicted in the immediate vicinity of the Ocean Laboratory structure, but these are no greater than those predicted in the immediate vicinity of each of the wind turbines. A comparison of Figures 8.7 and 8.10 indicates that the cumulative impacts of the Ocean Laboratory and the EOWDC does not induce a greater magnitude of change to the wave regime beyond that predicted by the EOWDC alone.

8.3.4.2 Introduction of seabed scour as a result of the cumulative presence of turbine foundations and the Ocean Laboratory

53 As with the wind turbine foundations, the Ocean Laboratory has the potential to create scour around its base. The scour extents calculated for the range of substructures considered in Section 8.3.3.2 indicates that scour is unlikely to extend more than 30 m from the centroid location of any structure. It is therefore not anticipated that there would be any interaction of scour between the foundations of the Ocean Laboratory and other wind turbines.

54 Additionally, the foundations are located within a staggered grid such that the rows are not tidally aligned, making it unlikely that there would be any interaction between the tidal wake of one foundation and another one downstream.

TABLE 8.5
Summary of Impact Assessment

Potential Impact	Significance Level	Mitigation	Residual Impacts	Monitoring
Phase: Construction and decommissioning				
Changes to processes acting within Aberdeen Bay as a result of the presence of construction equipment.	negligible	not required	not relevant	not required
Introduction of seabed scour as a result of the presence of construction equipment.	negligible	not required	not relevant	not required
Increase in suspended sediment concentrations as a result of foundation installation / removal activities	minor	not required	not relevant	optional
Increase in suspended sediment concentrations as a result of cable installation / removal activities	minor	not required	not relevant	optional
Phase: Operation				
Changes to processes acting within Aberdeen Bay.	negligible	not required	not relevant	not required
Changes to processes acting within Aberdeen Bay as a result of the cumulative presence of turbine foundations and the Ocean Laboratory.	negligible	not required	not relevant	not required
Introduction of seabed scour as a result of the presence of turbine foundations.	minor	recommended	negligible	optional
Introduction of seabed scour as a result of the cumulative presence of turbine foundations and the Ocean Laboratory	negligible	not required	not relevant	not required
Changes to processes acting to maintain the Aberdeen Bay coastline	minor	not required	not relevant	not required

8.4 Summary

55 Considerations of the proposed impacts upon the tide and wave regimes have been made and the subsequent effects upon a series of receptors determined. These receptors include the offshore sediment transport pathways, offshore seabed morphology and littoral sediment transport pathways. Comment has also been made to address relevant concerns raised by consultees. The assessment was undertaken using 'worst case' characteristics of the proposed development, as provided by the project. It is shown that the majority of potential impacts are considered to be of negligible significance. Exceptions are scour development, short term changes to suspended sediment concentrations and subsequent localised deposition, and slight changes in the coastal response to naturally occurring storm events, which are all considered to be of minor significance

8.5 References

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