NIRAS

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Note

Seagreen Wind Energy

Seagreen EIA Coordinator

Technical Note: Distribution and sensitivity of Nephrops and scallops in relation to sediment dispersal from gravity base structure installation

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Contents

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1 Introduction

The potential need for an assessment of the impact of suspended sediment and smothering of species such as scallops and *Nephrops* has been raised during scoping for the optimised Seagreen Project (see Section 2).

Notwithstanding the fact that the previous the 2012 Offshore Environmental Statement (ES) included assessment of the potential for such impacts arising from the use of gravity base structures, MS-LOT provided the following comments in their 2017 Scoping Opinion:

Advice from MSS (Marine Scotland Science) noted that the possible use of gravity base structures would require significant dredging operations and lead to increased suspended solids and increased smothering impacts. MSS note that structures such as monopoles or pin piles would not be likely to have such an effect.

Adult and larval scallops have a low tolerance to smothering and to increases in suspended sediment levels although adults are able to swim and may be able to escape the impacts. The behaviour and survival of scallop larvae and their ability to settle on suitable substrate would also be affected. Adult nephrops are more tolerant to smothering and to suspended solid load increases and decreases but MSS noted that more information on larval production, larval development and juvenile nephrops behaviour is required to understand the effect on these life stages. MSS note that the dredging would also have an effect by destroying populations of nephrops and by removing sediments best suited to burrowing and that re-colonisation/recovery would be prolonged.

If gravity base foundations are to be used, the Scottish Ministers advise that for fish and shellfish ecology further work to assess the impact of sediment on scallops and nephrops is carried out. The Scottish Ministers advise that the following two pieces of work be undertaken:

- A review of literature on effects of suspended sediments to scallops and nephrops (including different life stages); and
- Physical process modelling of likely spatial extent of suspended sediments from activities of concern.

These could be used to provide a comparison with the spatial extent of the scallop and nephrops fishery, identified from commercial fisheries data (e.g. Vessel Monitoring System ("VMS") data as described by Kafas et al (2012) and found online at Kafas et al (2013). This would allow an understanding of the spatial extent of effects, if any, to scallops and nephrops and provide a context within which to consider them. If Seagreen consider that there are no significant effects and scope this potential impact out of further assessment they must provide justification for this decision.

Information on scallops and *Nephrops* and potential sensitivity to the effects of smothering is included within Chapter 9 (Natural Fish and Shellfish) of the EIA Report. The following tasks completed in relation to physical processes are reported here:

1. Sediment Mobility Desk Study
   - Summary of existing sediment and metocean data presented in the 2012 Offshore ES.
   - Examination of the likely effects on seabed and sub-seabed sediments during the installation of Gravity Based Structures (GBS).

2 The Project

Seagreen Wind Energy Limited (hereafter referred to as 'Seagreen') is seeking consent to construct and operate two offshore wind farms (OWFs) Seagreen Alpha (hereafter referred to as 'Project Alpha') and Seagreen Bravo (hereafter referred to as 'Project Bravo') which collectively comprise 'the Seagreen Project' in the North Sea, in the outer Firth of Forth and Firth of Tay region (see Figure 1 below).

The Seagreen Project comprises the offshore wind farms (OWFs), together with the associated infrastructure of the offshore Transmission Asset and in 2014, Scottish Ministers awarded consent, for the construction and operation of these components (the originally consented project). However, Seagreen is now applying for additional consents for an optimised design (the optimised Seagreen Project) based on fewer, larger, higher capacity wind turbines that have become available since the 2014 consent decision. It is noted that the Offshore Transmission Asset has been licensed separately and no changes are proposed to these components.

This Note refers to the combined Project Alpha and Project Bravo Areas and an area to the west as 'Phase 1', since this term was used in material collated in support of the 2012 Offshore ES, which remains relevant and has been utilised here. The Phase 1 area is located within the wider Crown Estate Round 3 Zone 2 (Firth of Forth) as depicted on Figure 1 below. Similarly, information relating to the export cable route (ECR), which forms part of the Offshore Transmission Asset is also presented within some figures, but is not directly relevant.

For avoidance of doubt it should also be noted that the dimensions of gravity base structures and proposed seabed preparation works remain unchanged since the 2012 Offshore ES, although potentially fewer wind turbines would be installed given the proposal to deploy higher rated turbines.

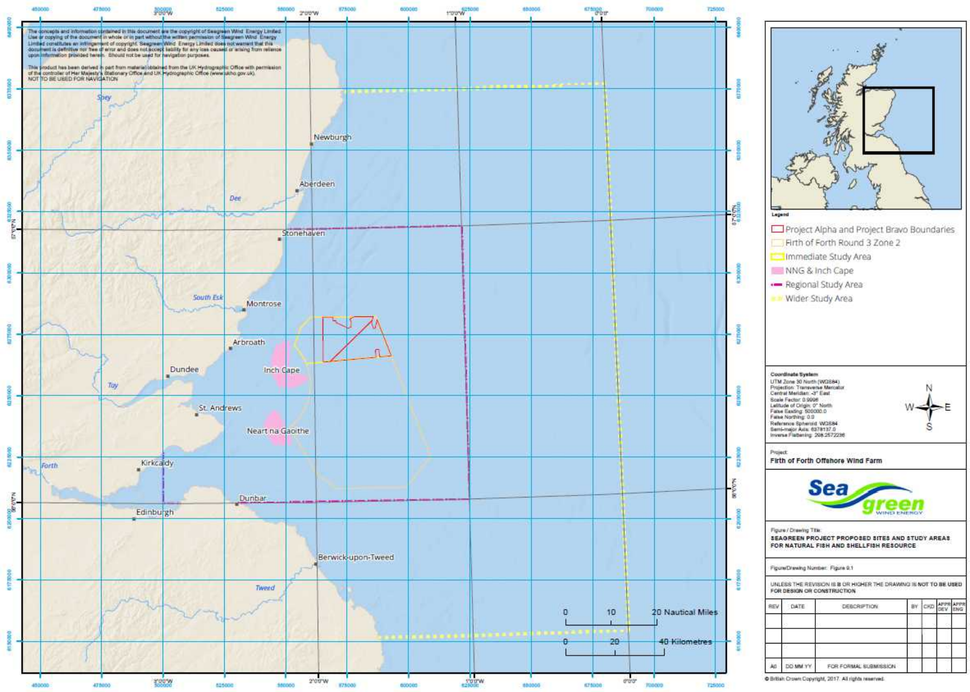


Figure. 1. Location of the optimised Seagreen Project.

3 Type and distribution of sediments

Based on grab and video samples, the seabed in the optimised Seagreen Project area is mainly composed of shelly sand, sand or gravelly sand sediments (Envision 2012). They are often observed to be rippled or to form larger mega-ripples. It is therefore likely that the sediments in the Phase 1 area are subject to some level of disturbance by currents. Some larger cobble size sediments were observed at many sites and, in some cases, sites were predominantly composed of cobbles (See Figs. 2, 3 & 4).

To note, these figures include information on the export cable corridor and as described above, this is not directly relevant to this EIA Report which is focused on activities in the optimised Seagreen Project Area.

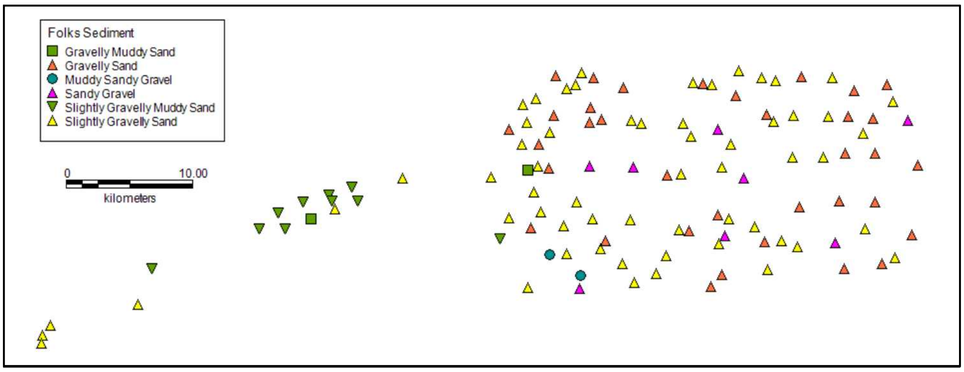
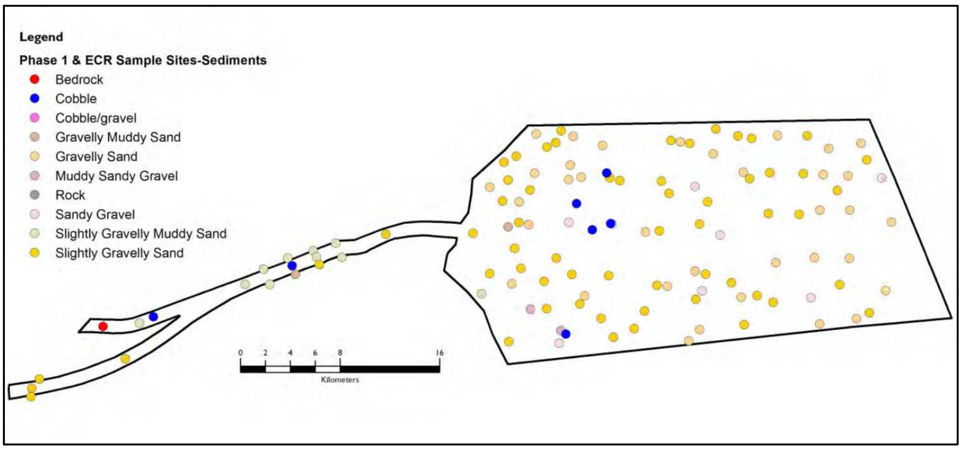


Figure. 2. Distribution of the PSA data (modified Folks) within the Phase 1 and ECR areas as classified by GEMS, 2012 (2012 Offshore ES).



Figuer. 3. Distribution of the sediment types within the Phase 1 area (from 2012 Offshore ES).

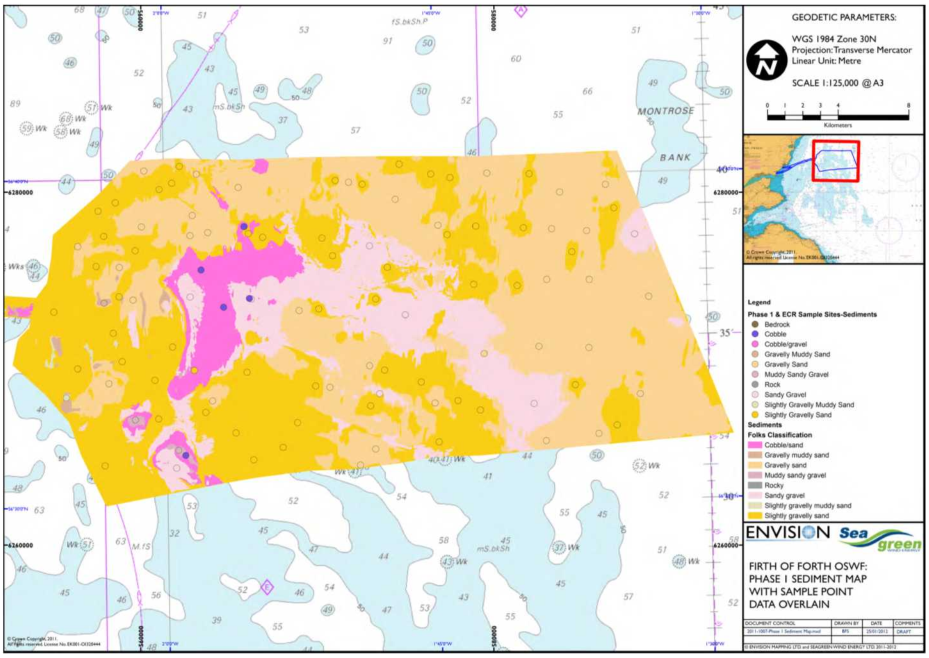


Figure. 4. Firth of Forth Zone, Phase 1 area predictive sediment map, overlain with sample site locations coloured by sediment type (from 2012 Offshore ES).

In their geophysical report, GEMS (2012) used side scan sonar and MAG data to build detailed bathymetric and slope maps of the Phase 1 area (Figure. 5 and Figure. 6).

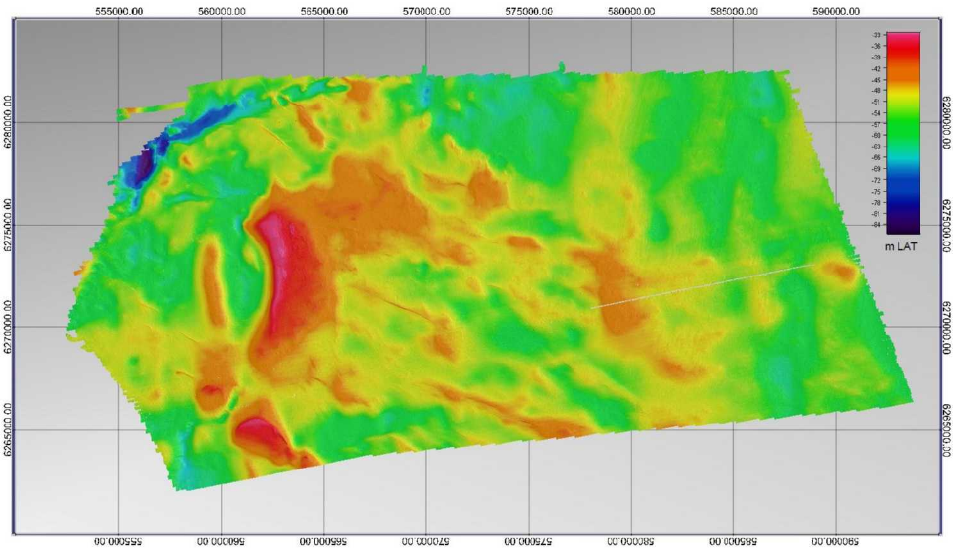


Figure. 5. Overview of bathymetry across the Phase 1 area (from 2012 Offshore ES).

The maximum depth was observed to the northwest of the Phase 1 Area in a deep northeast to southwest orientated channel. Conversely, the shallowest depths were observed along Scalp Bank, orientated in a north-south direction, outside and to the west of the optimised Seagreen Project Area (Seagreen 2012c).

Occasional areas of steeply sloping seabed were observed to the northwest of the Project Area. The majority of the site has a slight gradient (0 to 5°), however, where ripples, mega-ripples and sandwaves are found, localised gradients of <11.9° occur (Seagreen 2012c).

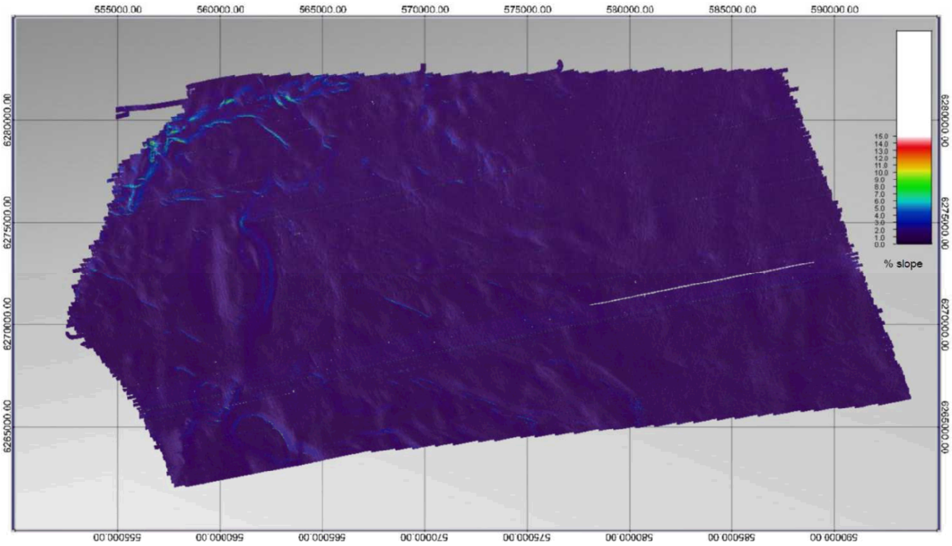


Figure. 6. Overview of slopes across Phase 1 area (from 2012 Offshore ES).

Sonar data was also used to identify sediment transportation features within the Phase 1 survey area, which included:

1. Ripples
2. Mega-ripples
3. Sandwaves

The aforementioned features (see Table.1) are characteristic of sediment transportation by currents. Mega-ripples were shown to be predominant in the area. These transportation features display a flow pattern that is approximately parallel to the coastline in a north-northeast to south-southwest direction, and vice versa with tidal flow. These features are also indicative of a current regime where currents are strong enough to move and potentially erode fine to coarse sand grade material.

Table. 1. Sediment Transport Features (GEMS 2012).

Terminology	**Definition**
Ripple	Undulations (<0.5m λ) produced by fluid movement (waves and currents) over sediments
Mega-ripple	Undulations (0.5m to 25m λ) produced by fluid movement (waves and currents) over sediments
Sandwave	Undulations (>25m λ) produced by fluid movement (waves and currents) over sediments

Geophysical data were also used in conjunction with borehole and cone penetration (CPT) data in order to build a stratigraphic model of the sub-seabed strata in the Phase 1 area (see Figure. 7 for borehole and CPT locations and Table. 2 for the resulting stratigraphy).

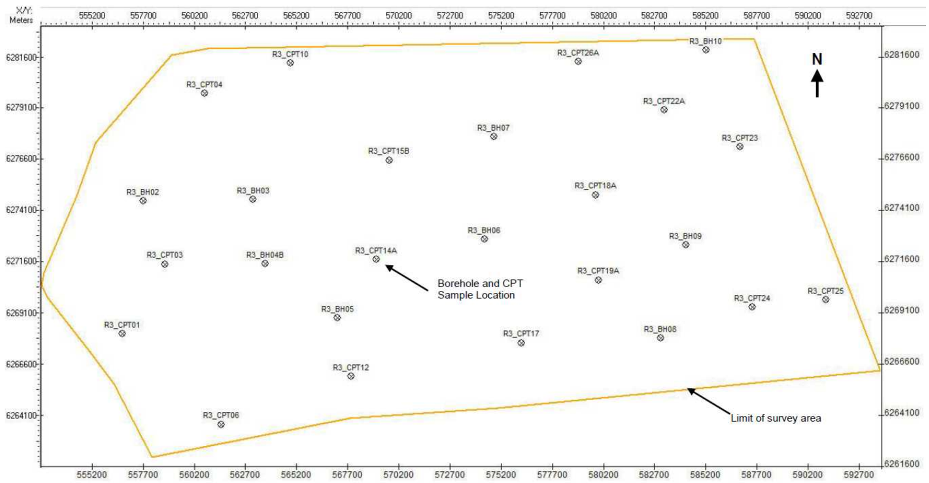


Figure. 7. Borehole Sample and Cone Penetration Test locations across the Phase 1 area (from 2012 Offshore ES).

Table. 2. Geological and stratigraphic summary.

Stratigraphy		**Depth (metres BSB)**	**Properties**	**Predicted Soils**
Holocene	Undifferentiated Holocene	Generally less than 0.5m thick	Superficial sediments: thin veneer of sediments generally less than 0.5m thick and locally absent.	SAND, slightly gravelly sand, gravelly sand and also some small patches of sandy GRAVEL
		Up to 35m to base of formation	Forth Formation: occurs as blanket spreads or occupies depositional hollows on the surface of the Wee Bankie Moraine, or late Weiselian channels. Internal erosion surfaces common. Mainly amorphous; some well-layered sediments in north and west. Present across most of the site.	SAND, fine grained, well to poorly sorted, soft to firm, olive to grey brown, with lithic pebbles, shells and shell fragments in variable amounts and some possible MUD/SILT towards its base. Fluviomarine.
	Wee Bankie Formation	Up to 63m to base of formation	Sheet-like deposit on rugged bedrock topography. Seismically amorphous, with occasional point source reflectors. Covers most of west of area; grades into Marr Bank Formation. **Generally <20m thick, up to 40m thick in some places.**	BOULDER CLAY, hard, dark grey to red-brown, gravelly, angular to rounded clasts, with thin interbeds of sand and pebbly sand. Basal till.
	Marr Bank Formation	0 to 38m to base of formation	Sheet-like deposit on flat basal surface. Seismically mainly amorphous with some faint mostly parallel layering. Covers most of east of area; grades into Wee Bankie Formation.	SAND, fine grained, poor to well sorted, soft to firm, grey to red-brown with abundant lithic granules and pebbles. Locally silty. Glaciomarine.
	Aberdeen Ground Formation	In excess of 85m to base of formation in places	Occurs at blanket spreads or occupies hollows of the underlying bedrock. Sub-parallel reflectors with transparent sections. Present across less than half of the site.	Interbeds of MUD, hard, brown to grey, and SAND, fine to coarse grained. Glaciomarine.
Triassic	Triassic group	more than 85m to top of formation in places	Underlying bedrock. Heavily folded and faulted. Strongly deformed succession of parallel reflectors with transparent sections. Present across whole site.	Red SANDSTONES, SILTSTONES, MUDSTONES AND MARLS, flat to current-bedded with sporadic thin bands of gypsum, intra-formational conglomerate and disseminated pseudomorphs after halite.

3.1 Holocene Sediments

In the Phase 1 area, Holocene sediments are of the greatest interest, as they will most likely be encountered when the wind turbine sites are prepared for GBS installation.

These Holocene sediments comprise mostly fine sand, with some finer sediments towards the base of the formation. These are overlain by a superficial covering of gravelly sediments as mentioned above. It is most likely that fine sand will be dredged during site preparation.

4 Metocean conditions

4.1 Wind and waves

Metocean data show that the Phase 1 area is often subjected to strong winds, and consequently waves (Seagreen 2012c). Wave heights, however, vary greatly due to fetch limitations and water depth effects (Figure. 8). Furthermore, waves in this area can be generated by either local winds or by more remote weather systems (i.e. swell waves).

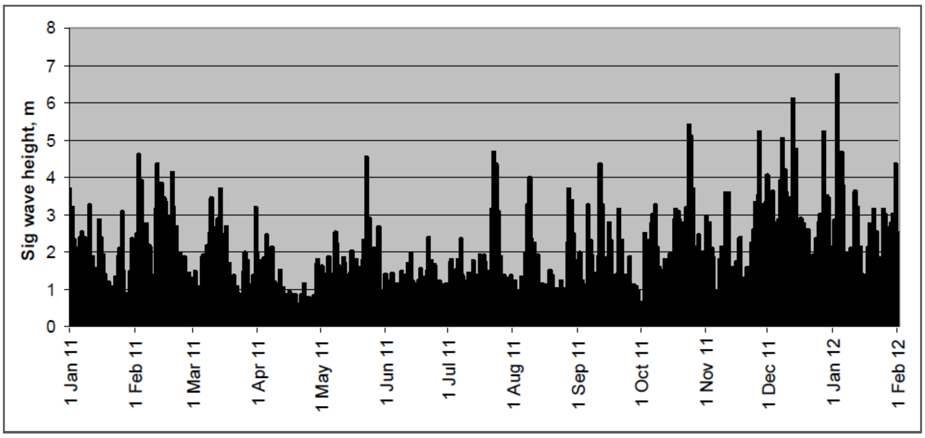


Figure. 8. Time-series record of significant wave height in the Phase 1 area (Seagreen 2012c).

Wind conditions in the west are influenced by the Firth of Forth corridor, leading to a predominantly south westerly wind. In the east there is a greater spread of wind directions across the south to western sectors.

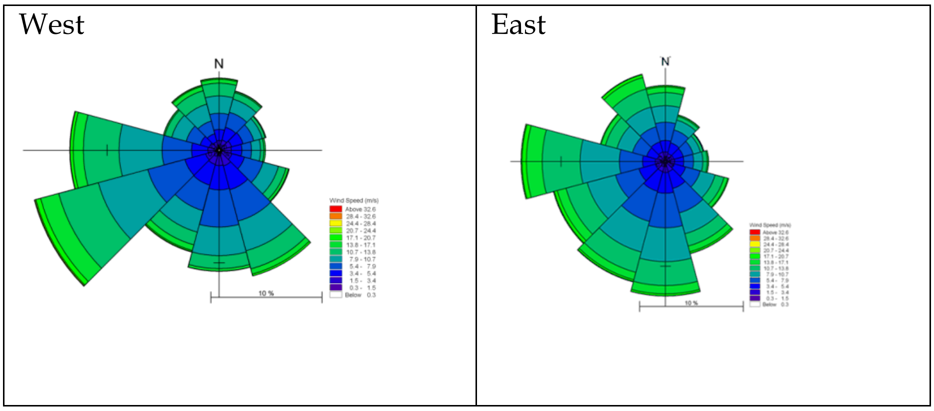


Figure. 9. Wind climate from Met Office model, west and east of the Phase 1 area (Seagreen 2012c).

The sea wave rose plots for the Phase 1 area show three dominant directions; south westerly, southerly and northerly waves.

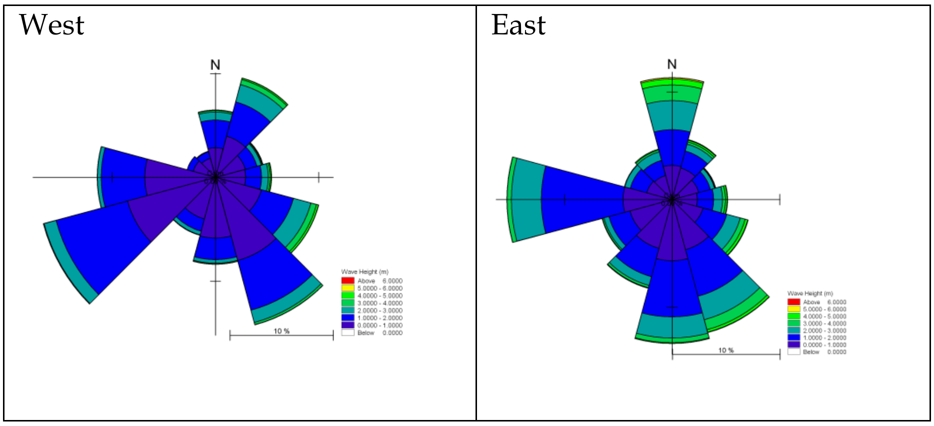


Figure. 10. Sea wave climate from Met Office model, west and east of the Phase 1 area (Seagreen 2012c).

Swell waves are from two directions; predominantly north easterly and south easterly.

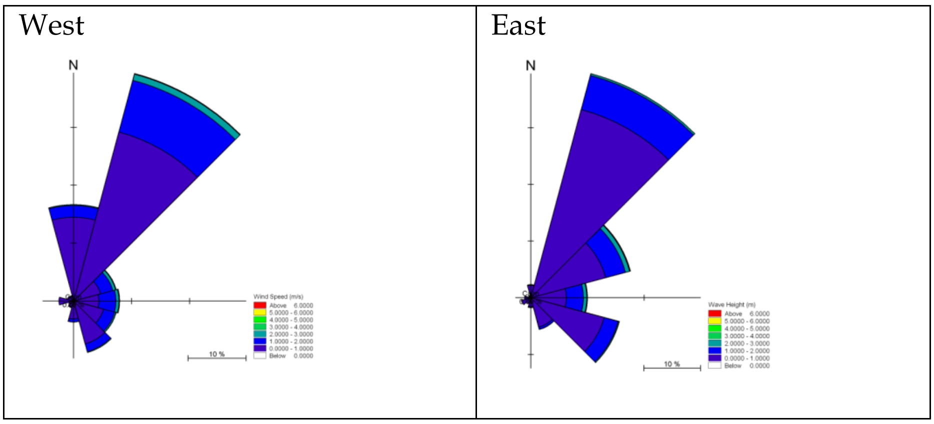


Figure. 11. Swell wave climate from Met Office model, west and east of the Phase 1 area (Seagreen 2012c).

The resulting waves are from three dominant directions in a descending order of dominance; north easterly, south easterly and south westerly (Figure. 12).

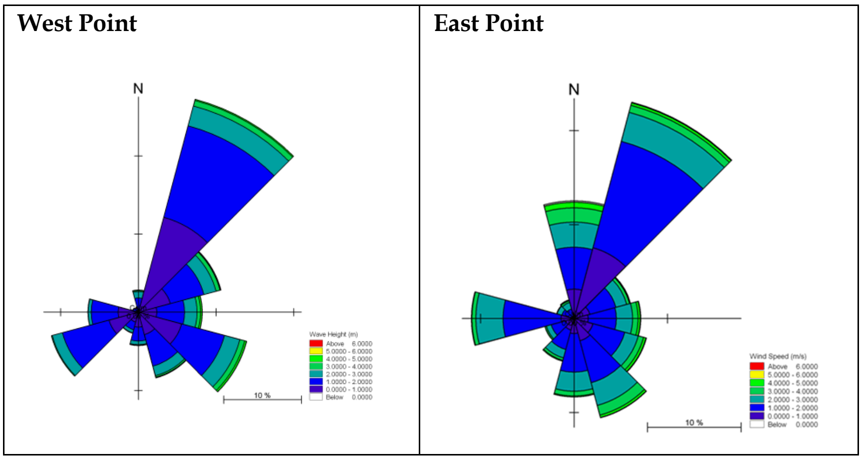


Figure. 12. Wave climate from Met Office model, west and east of the Phase 1 area (Seagreen 2012c).

4.2 Tidal currents

Table 3. below summarises the tidal current statistics for the Firth of Forth Zone.

Site	Depth (metres below mean sea-level)	Height (metres above seabed)	Speed (m/s)		Direction at Maxi-mum (°N)
			Maxi-mum	Mean	
A (AWAC)	10.5	43.0	0.91	0.35	029
A (ADCP)	45.25	8.25	0.74	0.28	017
B	8.8	52.7	0.88	0.32	196
C	7.3	50.7	0.72	0.26	000
D	6.1	48.7	0.77	0.28	178
G	9.8	44.7	0.72	0.26	001
H	10.0	43.0	0.76	0.23	136

Table. 3. Summary of tidal current statistics (Seagreen 2012c). Locations within the Phase 1 area highlighted orange.

The strongest currents were observed in the northern section of the Phase 1 area. These were measured as a maximum current of 0.91m/s on 18th April 2011, during a period of spring tides that correlated with the maximum water level. Figures. 13 and 14 show both current direction and velocities at 20.5 and 21.3 m water depth, within the Phase 1 area.

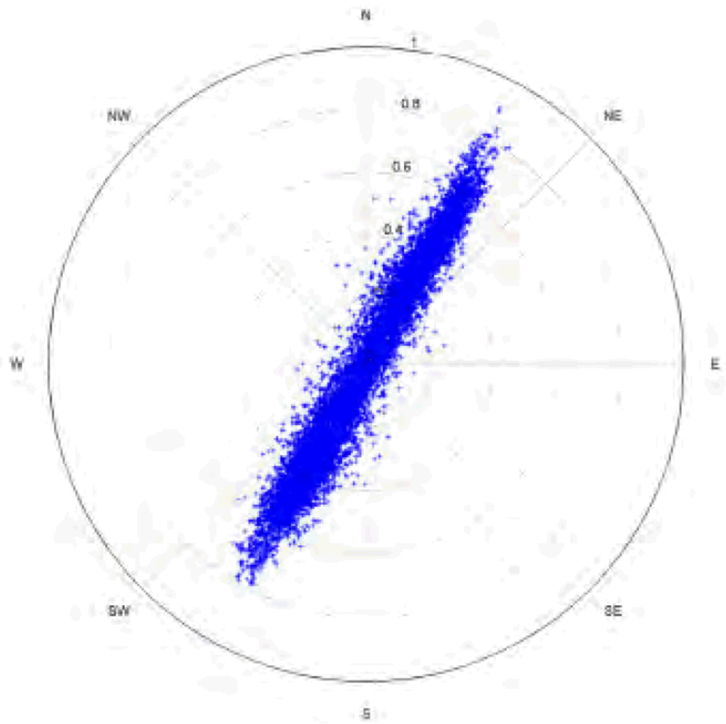


Figure. 13. Polar scatter plot of recorded current velocities at 20.5 m below mean sea level (24 march – 5 june 2011). Royal Haskoning, 2012.

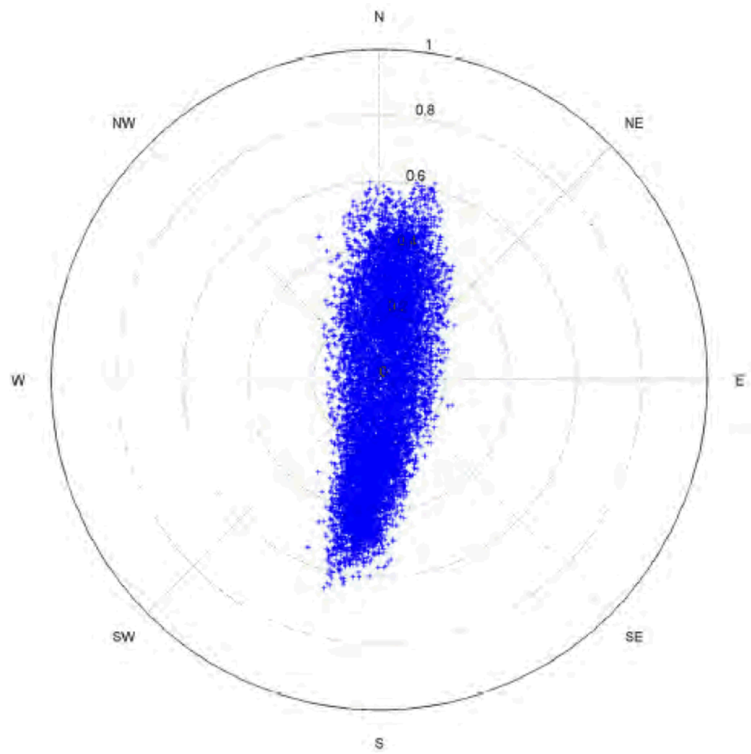


Figure. 14. Polar scatter plot of recorded current velocities at 21.3 m below mean sea level (24 march – 6 june 2011). Royal Haskoning, 2012.

4.3 Resulting suspended sediments

Water sampling carried out during two sampling events, in March and June 2011, showed total suspended solids (TSS) to be relatively low. See Table. 4.

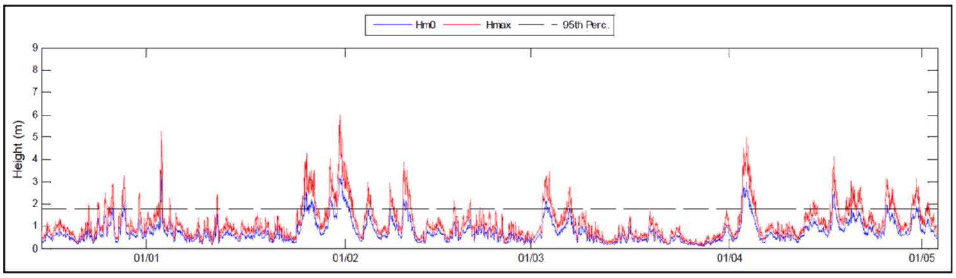
Site	Time after sampling started (mins.)	March					June				
		0	30	60	90	120	0	30	60	90	120
A	Top	10	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Middle	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Bottom	8	<5	5	6	<5	<5	<5	<5	<5	<5
H	Top	5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Middle	<5	<5	<5	10	<5	<5	<5	<5	<5	<5
	Bottom	6	18	<5	18	<5	6	<5	<5	<5	6

Table. 4. Total Suspended Solids (mg/l), March and June 2011 within the Phase 1 area, Seagreen 2012c.

"Tidal currents are the principal mechanism governing suspended sediment concentrations in the water column, with fluctuations across the spring-neap cycle and throughout different stages of the tide (high water, peak ebb, low water, peak flood) observed throughout both datasets. However, suspended sediment concentrations can temporarily be elevated by wave-driven currents during storm events" (Seagreen 2012c).

Figure. 15. Shows a direct correlation between wave height and suspended solids within the Phase 1 area.

a



b

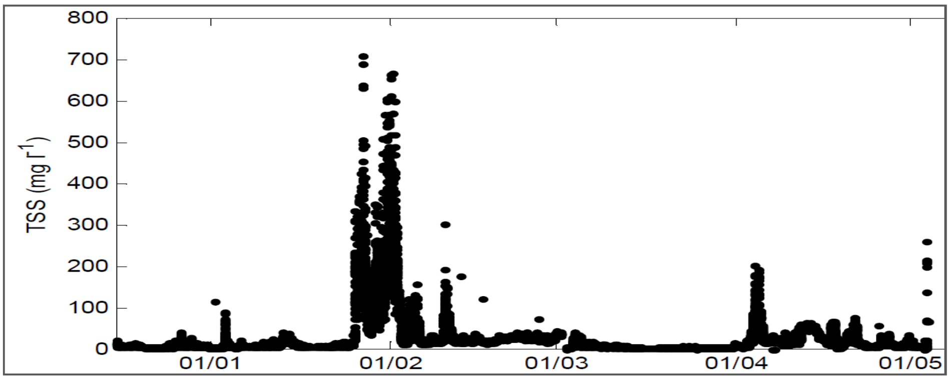


Figure. 15. Relationship between wave height (a) and total suspended solids (b), Phase 1 Area, Seagreen 2012c.

4.4 Suspended sediments associated with site preparation

Experience has shown that suspended sediment concentrations may become elevated during the seabed preparation activities associated with the installation of GBS foundations. Sediments brought into suspension depend on the volume and character of material disturbed during site preparation.

It was stated in the 2012 Offshore ES that "the exact volume of seabed preparation at each location and the precise methods to be used are not fully defined and remain subject to ongoing design optimisation" (Seagreen 2012c). The design envelope for the optimised Seagreen Project has been developed and it is currently understood that parameters will be as detailed in Table 5.

Table 5. Summary gravity base design envelope parameters for Seagreen Project.

	Project Alpha	Project Bravo	Combined
Maximum number GBS foundations	70	70	120
Seabed excavation area for each foundation (m)	72x72	72x72	-
Excavation depth (m)	3	3	-
Maximum excavation volume per foundation (m^3)	16,000	16,000	
Maximum excavation volume for site (m^3)	1,120,000	1,120,000	2,240,000

The 2012 Offshore ES concluded that as the critical threshold for particle motion is exceeded only during part of the spring neap tidal cycle, the likelihood of widespread sediment dispersal in high concentrations is low. Also, if the proposed schedule for GBS site preparation occurs in phases over a minimum 6 month period, "with no more than two substructures/foundations being installed simultaneously at any one time", the excavated material will become indistinguishable from the background sediment in a matter of days. Seagreen therefore concluded that the consequent sediment transport and deposition of sediment on the seabed would represent a low magnitude effect.

5 Installation of gravity based structures & site preparation

Gravity based structures need to be placed on a flat and level surface to ensure that the weight of the structure is evenly distributed and vertical. This, more often than not, requires that the seabed is excavated to remove unstable sediments, or unwanted obstructions, such as boulders. The preferred method is to place the GBS directly on to the seabed. Following preparation of a foundation site, it may require further levelling with a gravel layer, or grouting.

Figure. 16 depicts the type of GBS foundations that could be installed.

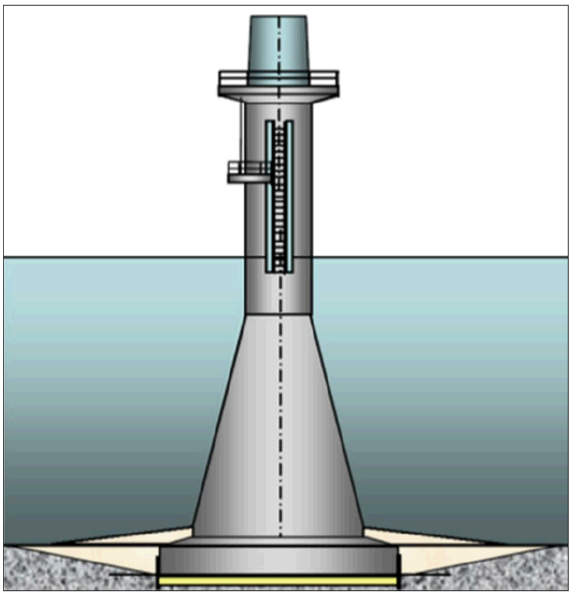


Figure. 16. Conical GBS foundation with monotower (Seagreen, 2018)

A GBS usually requires seabed preparation over the footprint area, to ensure a uniform load distribution and vertical alignment (Garrad Hassan, 2011). This typically involves dredging to remove superficial sediments followed by rock and/or gravel placement to form a level footing. Specialist dredgers and rock placement vessels will be used for these operations which would be monitored using ROVs. The dredging and ground preparation method adopted will be determined through the detailed ground investigations undertaken during detailed design.

Site selection will seek to minimise the extent of ground preparation required. For the majority of the site for average strength soils an average seabed preparation depth of up to 3m is assumed. If weaker strength soils are encountered greater seabed preparation depth may be required, however these locations will be avoided where possible.

The surplus material produced during the ground preparation and seabed levelling will be disposed of in-situ, either on the seabed adjacent to the substructure or re-used as a ballasting medium for the substructure. The materials likely to be produced from the seabed preparation for GBS' comprise deposits of sand and gravel with occasional potential for clay where present close to the surface. Seagreen will investigate the potential to maximise reuse of arisings from ground preparation as ballast.

Skirts around the perimeter of the GBS (to a depth of 5m) can be used to minimise or even remove the requirement for seabed preparation. These skirts also assist in the protection of the structure from scour. When skirts are used, grout is required to fill any gaps under the base slab.

6 Modelling in analogous environments

During the construction phase, seabed preparation requires dredging this will result in sediment spill. The spilled sediment will enter into suspension and will be dispersed into the surrounding areas by currents, until it settles back onto the seafloor. Depending on the size of the sediment, it can become re-suspended by wave and current action. The distance which this increased concentration of suspended sediment can travel is dependent on a number of variables, such as current direction and speed, and of course the characteristics of the sediment itself. Fine sediments such as silts and muds, have a much lower settling velocity than sand, for example, and are consequently transported further away from the dredging site. Whereas, sand typically settles in or close to the excavation area (MariLim 2015).

Numerical modelling has been used at several North Sea offshore wind farm sites to predict the likely amount of suspended sediments resulting from the preparation of the seabed, prior to the installation of gravity based structures. A number of suspended sediment model results are presented below, all of which are modelled in areas with *similar seabed sediment size/distribution and metocean conditions* to the optimised Seagreen Project area unless otherwise indicated (Hornsea). All sites are also located in relatively shallow coastal sites where typical water depths are comparable with the optimised Seagreen Project, for the purpose of inferring broad conclusions about the propensity of equivalent activities to mobilise suspended sediments.

6.1 Vesterhav Nord

The method used here models sediment placed in suspension in the water column during the construction phase and thereafter predicts the spatial and temporal concentrations in the impacted area around the excavation site. The model assumes that the seabed is being prepared for installation of 3 MW turbines on a gravity foundation.

Results showed an average increase of suspended sediment around the dredged area of below 6 mgl^{-1} when compared to background concentrations. Outside the windfarm subarea average increased concentrations were predicted to be less than 3 mgl^{-1} (COWI 2015). At some locations the predicted increases in concentration reached as high as 10–20 mgl^{-1} above background, however this was short lived. The increases of suspended sediment concentrations predicted using this method are in keeping with the natural background conditions in this area. In terms of length of time in suspension, the durations predicted here were too short to be regarded as a disturbance in relation to the natural background conditions. (Figure. 17; COWI 2015)

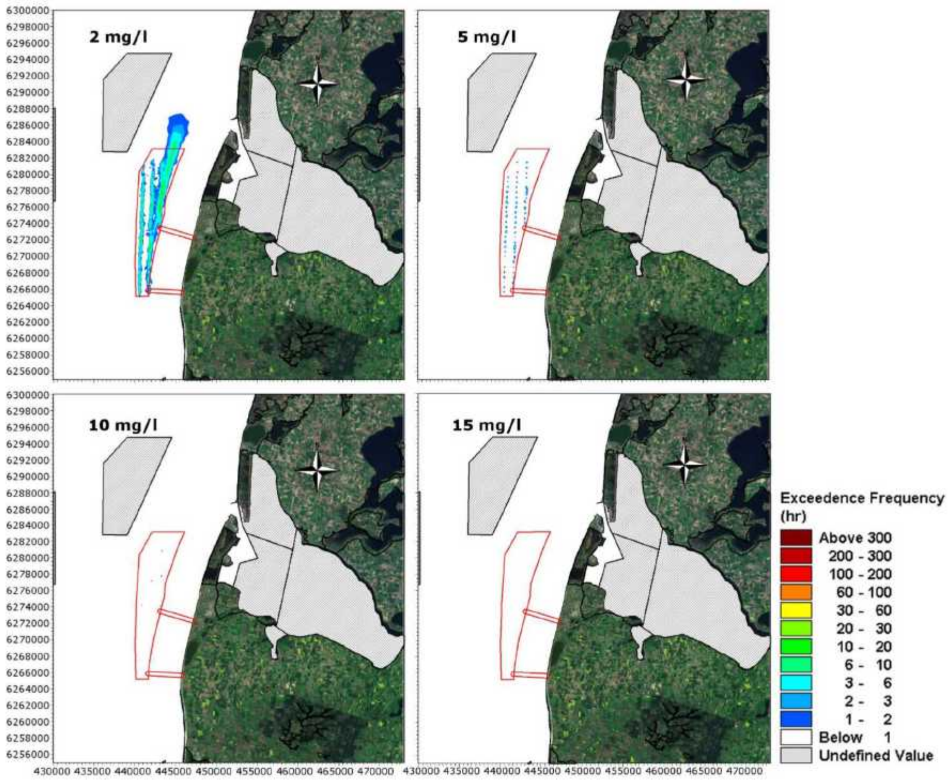


Figure. 17. Exceedance time of suspended sediment concentration of 2 mgl-1 (top, left), 5 mgl-1 (top, right), 10 mgl-1 (bottom, left) and 15 mgl-1 (bottom, right) as average of the water column for wind turbine foundations (scenario 1) (from COWI 2015; MariLim 2015).

Figure. 18. shows the total predicted deposition of spilled sediment two weeks after the cessation of dredging/excavation works. Inside the OWF area (red lines) the spilled sediment was predicted to deposit around 50-100 g/m^2, in a few exceptions (near excavation sites), deposition of up to 400 g/m2 was predicted. Very little sedimentation is expected to occur outside the OWF area (up to 50 g/m^2 north of the OWF). Figure. 19. shows that a threshold sedimentation rate of 2.5 g/m^2/hour (or 60 g/m^2/day), above which mussel larvae growth may be inhibited (COWI, 2015) is not exceeded at any point during the dredging/excavation works (MariLim 2015).

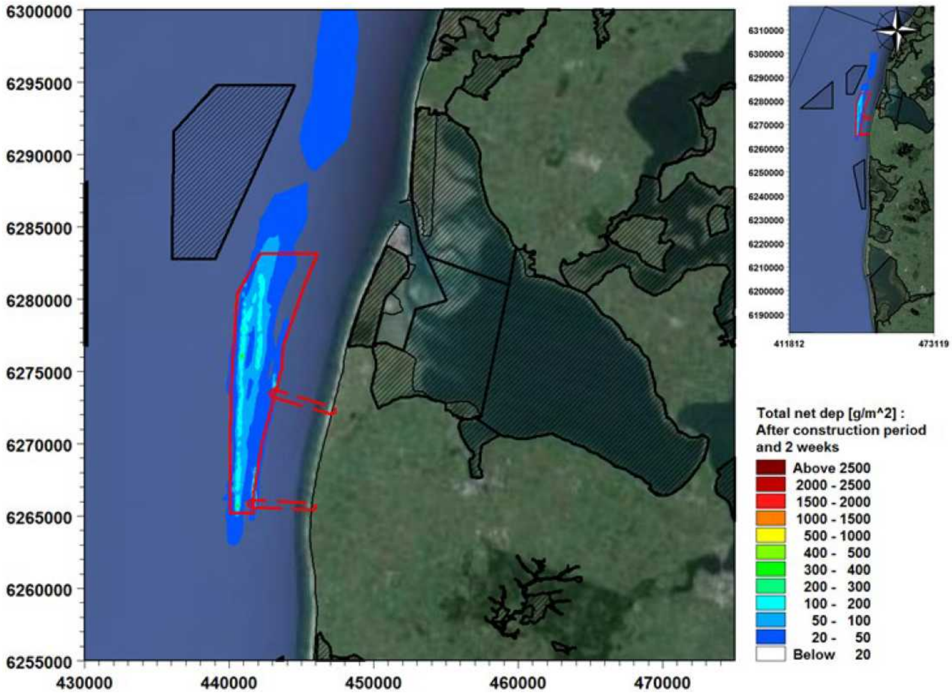


Figure. 18. Total net deposition of spilled sediment two weeks after the cessation of dredging/ excavation works for foundations. Hatched areas with black frames are Nature 2000 areas (from COWI 2015; MariLim 2015).

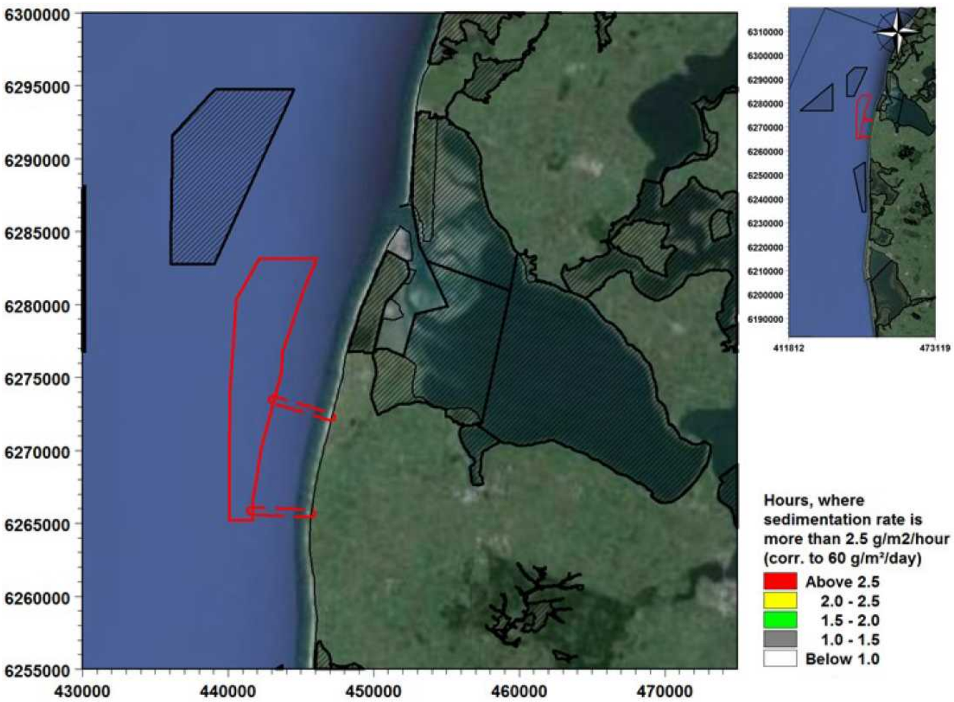


Figure. 19. Hours with sediment rate more than 2.5 $g/m^2/hour$ (or 60 g/m2/day), during dredging/ excavation works for foundations. Hatched areas with black frames are Nature 2000 areas (from COWI 2015; MariLim 2015).

Figures. 18 and 19 (above) show the maximum predicted deposition rate and erosion rate of spilled material during dredging/excavation works. While these are below the threshold sedimentation rate (of 2.5 $g/m^2/hour$ relating to possible impaired mussel growth), the highest deposition rates are predicted to be close (within metres) to all excavation sites.

Figure. 20 shows the predicted net deposition rate of spilled sediment during dredging works.

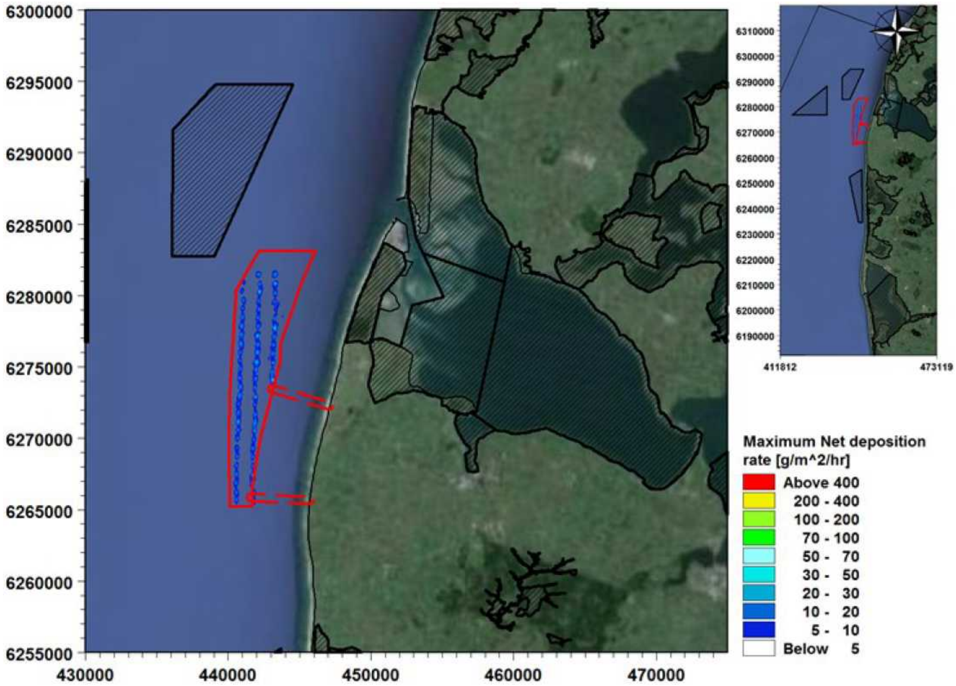


Figure. 20. Maximum net deposition rate of spilled sediment during the foundation dredging/excavation works. Hatched areas with black frames are Nature 2000 areas (from COWI 2015; MariLim 2015).

6.2 Horns Rev 3

The model used here predicts that increases in suspended sediment concentrations, resulting from site excavation, are mainly limited to areas adjacent to the foundations (Orbicon & Royal Haskoning 2014). Furthermore, the modelling also predicts that the overall sediment plume would most likely be restricted to the pre-investigation area. Moreover, the plumes generated at each excavation site are predicted to be of modest magnitude.

Given that the natural suspended sediment concentrations in this area can be very high, particularly during storm conditions, the impact of any additional suspended sediment into the water column related to dredging will be low (Orbicon & Royal Haskoning 2014).

Figure. 21 (below) shows the predicted maximum suspended sediment concentration over the 30-day simulation period for seabed preparation only. Predicted suspended sediment concentrations are shown to increase locally at each of the excavation site locations by up to 1.5mg/l, there is no apparent interaction between any of the plumes.

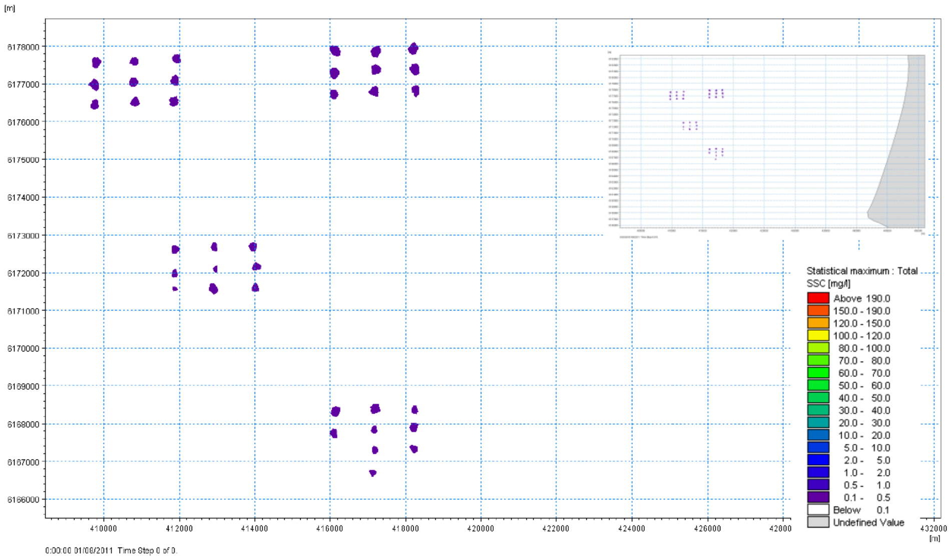


Figure. 21. Maximum suspended sediment concentration (mg/l) predicted over the simulation period for the construction phase for GBS foundations, including the coast (insert) and zoomed in (main). From Orbicon & Royal Haskoning, 2014.

Figure. 22 (below) shows predicted suspended sediment concentration for seabed preparation and inter-array cable installation combined. Predicted maximum suspended sediment concentrations increase significantly (to more than 200mg/l) when the effect of inter-array cable jetting is also considered, however, it should be noted that this is very unlikely to take place in close proximity to GBS installation at the same time at the optmised Seagreen Project. Most importantly, predicted suspended sediment concentrations reduce to zero within 500m of the foundations and cable transects in all directions (Orbicon & Royal Haskoning, 2014).

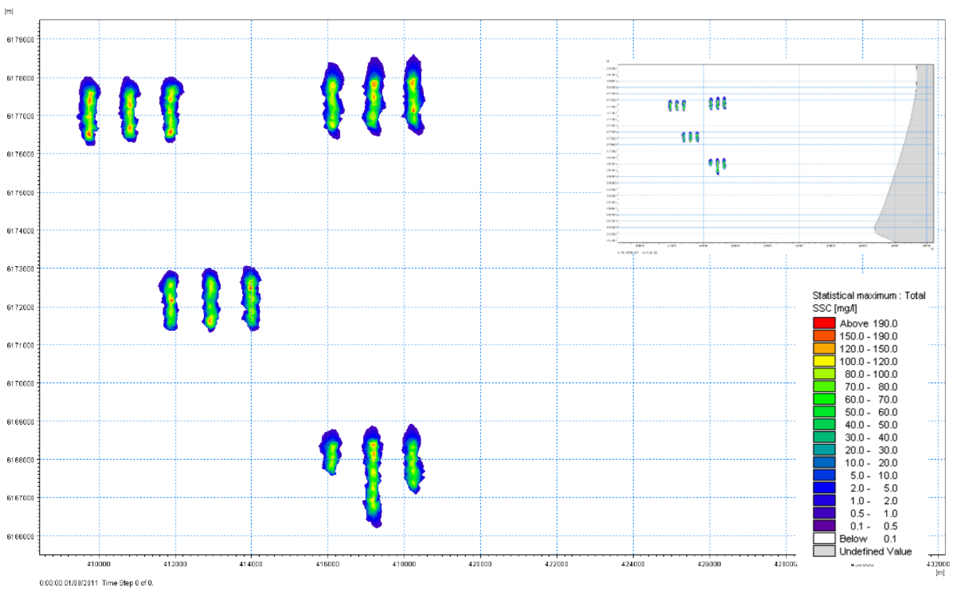


Figure. 22. Maximum suspended sediment concentration (mg/l) predicted over the simulation period for the construction phase for GBS foundations and inter-array cable installation combined, including the coast (insert) and zoomed in (main). From Orbicon & Royal Haskoning, 2014.

The largest predicted deposition of sediments from suspension is c. 8mm, close to a few of the excavation sites. The majority of deposition is between 2 and 4mm (see Figure. 23). As before, when the cumulative effects of seabed preparation and cable installation are considered, the largest predicted deposition increases to approximately 50mm, limited to locations close to the excavation sites. Additional deposition, the majority of which is between 10mm and 15mm, is limited to within approximately 200m of the foundations and does not extend to the coast (Figure.25).

Given the dynamic environment (waves and currents) and sandy nature of the sediments at the Horns Rev 3 offshore wind farm site, deposition of sediment predicted here was considered to be of little significance when compared with the natural variation of bed level changes across the area. Thus, the impact of additional deposition of sediments on the seabed related to GBS site dredging and installation of inter-array cables was considered to be low.

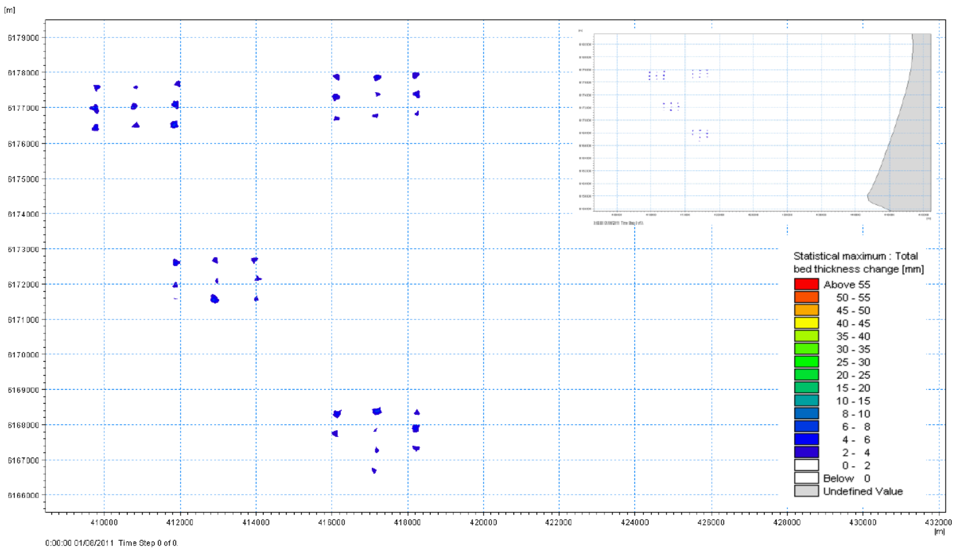


Fig. 23. Deposition (mm) from plume for the construction phase for GBS foundations, including the coast (insert) and zoomed in (main). From Orbicon & Royal Haskoning, 2014.

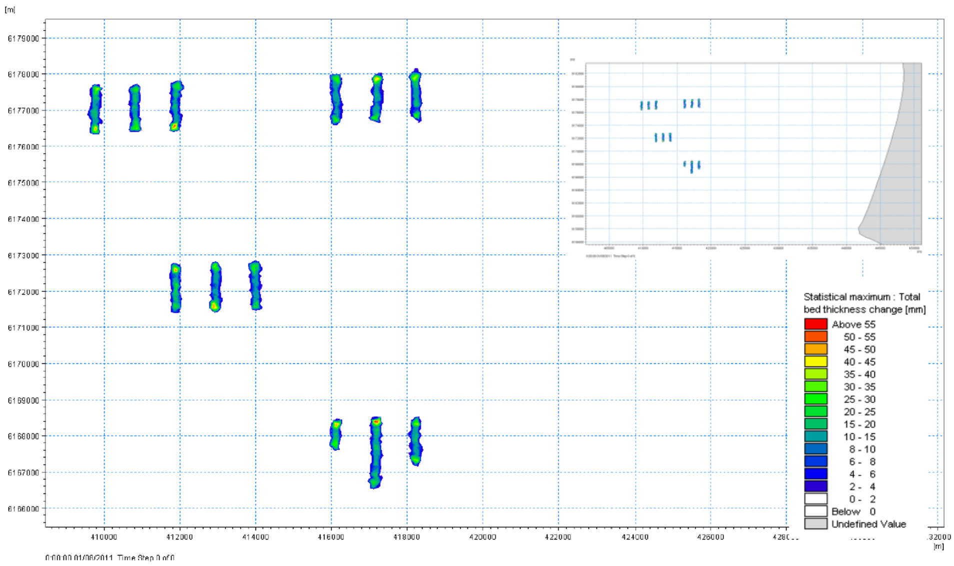


Fig. 24. Maximum deposition (mm) from plume for the construction phase for GBS foundations and inter-array cable installation combined, including the coast (insert) and zoomed in (main). From Orbicon & Royal Haskoning, 2014.

6.3 Hornsea

To simulate the effects of dredging for gravity base foundations at the four locations (see Figure. 26) dredging was assumed in each case to a depth of 5 m. The dredger was assumed to be of 11,000 m^3 capacity and to travel at 0.5 m/s backwards and forwards across the dredging site (Smartwind 2015).

During this simulation there were two sources of sediment release: the dredging and the disposal (both understood to be at the same site, but at different times). The highest predicted increase in suspended sediment concentration was primarily generated by the dispersion from disposal while the plume resulting from excavation was predicted to be less significant and therefore more quickly dispersed by tidal currents (Smartwind 2015).

For dredging/disposal at Locations 1 and 2, peak increases in depth-averaged concentration of more than 2 mg/l above background were predicted up to 16 km NW and up to 14 km SE of the drilling location, although it should be noted that these figures are for sediments significantly finer than fine sand and coarser sediments which dominate the optimised Seagreen Project area. Increases in the depth-averaged concentration of more than 10 mg/l were predicted for Locations 1 and 2, and extending in length up to 12 km NW and about 13.5 km SE from the dredging/disposal location, again with finer sediments.

For dredging/disposal at Locations 3 and 4, peak increases in the depth-averaged concentration of more than 2 mg/l above background were predicted up to 14 km NW and up to 11 km SE of the dredging/disposal location, these figures are also for sediments significantly finer that fine sand. Predicted increases in depth averaged concentrations of more than 10 mg/l were predicted to extend up to 4 km NW and about 5.5 km SE from the dredging/disposal location, again with finer sediments.

Figure. 25 shows the predicted peak increase in depth-averaged concentration for the four simulated locations of sediment release (disposal). Despite apparent high values of concentration above background in close proximity to the dredge sites, these high values were localised and short-lived as illustrated in the time-series graph (Figure. 26) of predicted concentration increases at Location 1. The time-series prediction demonstrates that the predicted peak in suspended sediment concentration lasts for approximately one hour, and that these return to background levels approximately 27 hours after the start of the release (Smartwind 2015).

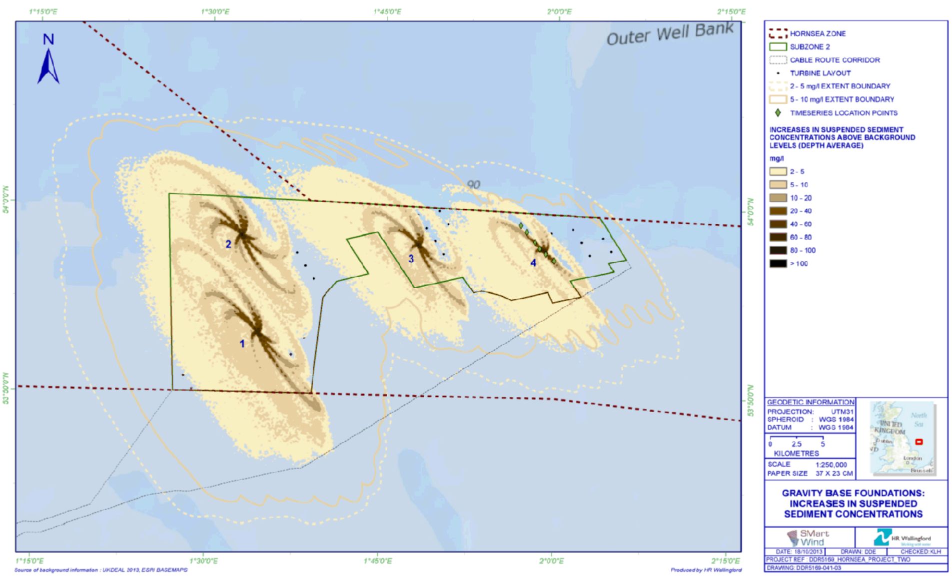


Figure. 25. Model output showing peak predicted depth averaged suspended sediment concentrations above background (mg/l) during seabed preparation for gravity base foundations (from Smartwind 2015).

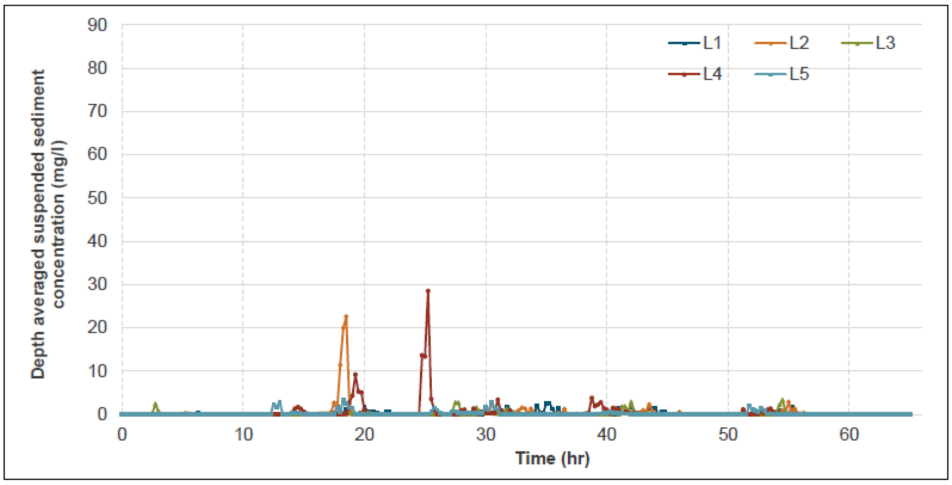


Figure. 26. Time-series of predicted depth-averaged suspended sediment concentration (mg/l) above background during gravity base foundation preparation at Location 1 in Figure 25 (from Smartwind 2015).

Predictions showed that sediment deposits were likely to be localised to the vicinity of the dredge and disposal sites. Only a thin deposit (up to 1 mm) of sand was predicted close to the dredging sites, with negligible deposition of fine sediment. Deposition of a few centimetres of fine sediment was predicted near to the disposal location.

7 Summary of sediment mobility in relation to gravity base installation

Although the preparation (dredging/excavation) of the seabed, prior to the installation of GBS foundations will evidently place an amount of sediment into suspension, this is expected to be short-lived and generally confined to an area close to the dredged site.

Considering the dynamic environment (waves and currents) and sandy nature of the sediments at the optimised Seagreen Project area (analogous to the sites and metocean conditions at Vesterhav Nord, Horns Rev 3 and Hornsea), the evidence from modelling studies at these locations is that the additional deposition of sediment, associated with seabed preparation works, is likely to be of little significance when compared with the natural variation of bed level changes across the area. This is supported further, by the time-series prediction (Figure. 26), which highlights the fact that predicted peak in suspended sediment concentration last for a short period of time (approximately one hour), and that sediment concentrations return to background levels after approximately 1 day. In this context it is worth noting the sharp increase in suspended sediment levels associated with storm events which occur naturally in the optimized Seagreen Project area (Figure 15b).

Increases in suspended sediment levels are expected to be limited to hundreds of meters from the activity, with deposition, typically to a few mm in relation to excavation and a few cm in relation to disposal of any arisings, also expected to be limited to some hundreds of meters.

It is likely that fewer, larger turbines will be used for the optimised Seagreen Project than those proposed in the 2012 offshore ES. Whilst no change to the size of GBS foundations required to support such turbines is expected, any reduction in numbers will be beneficial in terms of overall environmental impact.

In general terms, the impact on sediments placed into suspension is expected to be lessened where there is installation of fewer (larger) turbines. It is estimated that sediment spill has a lower magnitude when preparing the seabed for larger wind turbines, as the maximum amount of sediment removed and placed into suspension is higher for a greater number of smaller turbines than for a smaller number of larger ones.

These conclusions are consistent with the 2012 Offshore ES and it is not considered here that further work, such as physical process modelling, is necessary to provide a refined analysis for the optimised Seagreen Project area.

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