

Norfolk Vanguard Offshore Wind Farm

Appendix 12.6

Further scenarios for Cumulative Impact Assessment

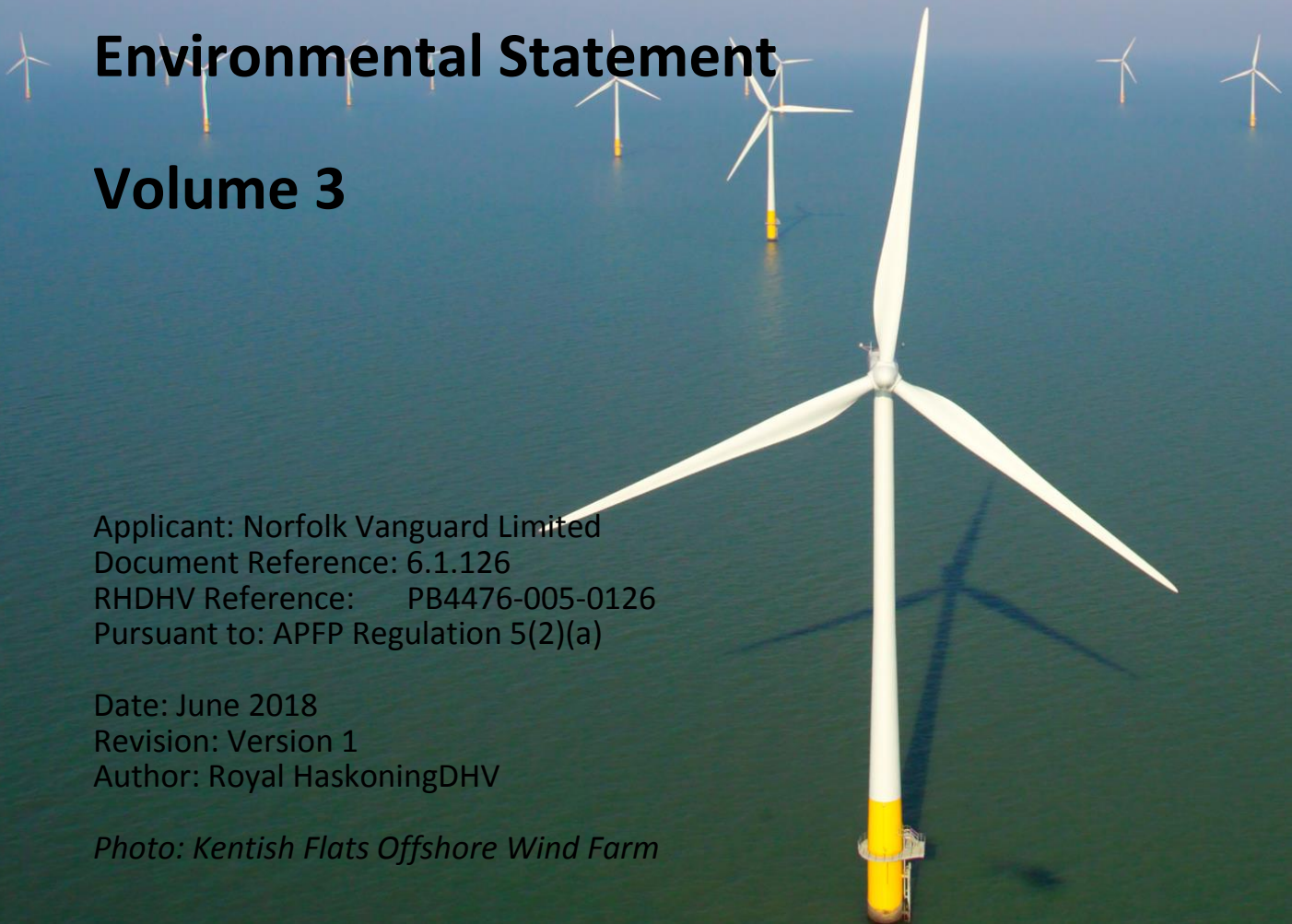
Environmental Statement

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For and on behalf of Norfolk Vanguard Ltd

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Date: 8th June 2018

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Glossary

CIA	Cumulative Impact Assessment
ES	Environmental Statement
GS	Grey seal
HP	Harbour porpoise
HS	Harbour seal
Km ²	Kilometre squared
MU	Management Unit
MW	Mega watt
NS	North Sea
NV	Norfolk Vanguard
OWF	Offshore Wind Farm
SCANS	Small Cetaceans in the European Atlantic and North Sea
UK	United Kingdom

1 UNDERWATER NOISE IMPACTS DURING CONSTRUCTION FROM OFFSHORE WIND FARM PILING

1.1 Theoretical Worst Case Scenario

1. A 'theoretical worst-case' scenario, based on potential construction periods which allows for any delays and changes in project development has been assessed. For this approach, all Tier 3 UK and European OWF projects (i.e. projects which have been consented, but construction has not yet commenced) have been assessed based on a seven year construction window from the year of consent to determine their potential overlap with Norfolk Vanguard (this is a precautionary approach as some project have five year consent window). All current UK Tier 4 OWF projects (i.e. projects which have an application submitted to the appropriate regulatory body that have not yet been determined or are consented) have been included in this theoretical scenario, with the possible construction windows based on the best available information. In addition, Tier 5 UK OWF projects (i.e. projects that the regulatory body are expecting to be submitted for determination / projects listed under the Planning Inspectorate programme of projects) have been listed and included in the theoretical worst-case scenario for in-combination effects during OWF piling although there is more uncertainty regarding, if and when, they could be constructed due to a lack of available information.
2. The UK Tier 3, 4 and 5 OWF projects (see Chapter 12 Marine Mammals section 12.4.2, Table 12.10 and Section 12.8.1 and Table 8.25 of Chapter 8 Marine Water and Sediment Quality for definitions) included in the theoretical worst-case scenario to assess the potential for in-combination effects of disturbance to harbour porpoise during OWF piling, based on the periods of construction and piling are outlined in Table 1. The European Tier 3 OWF projects included in the theoretical worst-case scenario, based on the periods of construction, where available, are also outlined in Table 1.

Table 1 Offshore wind farms included in cumulative impact assessment (CIA) for the potential disturbance of harbour porpoise (HP), grey seal (GS) and harbour seal (HS) where there is the potential of piling occurring at the same time as piling at Norfolk Vanguard. All details presented are based on the most up to date information for each project at the time of writing.

Name and country of project	Distance from NV	Size (MW)	Maximum number of turbines	Month/year consent authorised/ expected (7yr construction window)	Dates of offshore construction / piling ¹	'Worst-case scenario where potential 7-year consent window overlaps with Norfolk Vanguard construction period ²
Norfolk Vanguard	0	1,800	120-257	2019 (2019-2024)	Construction and piling: 2024 – 2028	Yes
Tier 3: consented						
Creyke Beck A, UK	163	500-600	200	Feb-15 (2015-2022)	2021-2027	Yes (HP, GS, HS)
Creyke Beck B, UK	193	500-600	200	Feb-15 (2015-2022)	2021-2028	Yes (HP, GS, HS)
Teesside A, UK	180	1,200	200	Aug-15 (2015-2022)	2021-2028	Yes (HP, GS, HS)
Sophia (formerly Teesside B), UK	175	1,200	200	Aug-15 (2015-2022)	2020-2028	Yes (HP, GS, HS)
East Anglia One, UK	40	714	102	Jun-14 (2014-2021)	Piling: 2018-2019	No
East Anglia THREE, UK	0	1,200	172	Aug-17 (2017-2024)	Piling: 2020 – 2022	Yes (HP, GS, HS)
Hornsea Project Two, UK	95	1,800	225	Aug-16 (2016-2023)	2018-2021 Piling: 2018-2020	Yes (HP, GS, HS)
Triton Knoll phase 1-3, UK	288	1,200	288	Jul-13 (2013-2020)	2018-2021	Yes (HP, GS, HS)
Kincardine	535	49.6	8	2017 (2017-2024)	2018-2019	Yes (HP)
Mermaid (Belgium)	125	366-288	24-48	2015 (2015-2022)	2017-2019	Yes (HP, GS, HS)

Name and country of project	Distance from NV	Size (MW)	Maximum number of turbines	Month/year consent authorised/ expected (7yr construction window)	Dates of offshore construction / piling ¹	'Worst-case scenario where potential 7-year consent window overlaps with Norfolk Vanguard construction period ²
Norfolk Vanguard	0	1,800	120-257	2019 (2019-2024)	Construction and piling: 2024 – 2028	Yes
Northwester 2 (Belgium)	130	224	22-38	2015 (2015-2022)	Unknown	Yes (HP, GS, HS)
Delta Nordsee 1 (Germany)	300	210	35	2005	Piling to commence in 2023	Yes (HP, GS, HS)
Delta Nordsee 2 (Germany)	300	192	32	2009	Piling to commence in 2023	Yes (HP, GS, HS)
Borssele I and II (Netherlands)	133	350+350	95+95	May-16 (2016-2023)	2019	Yes (HP, GS, HS)
Borssele III and IV (Netherlands)	123	360+340	95+95	May-16 (2016-2023)	2020	Yes (HP, GS, HS)
Borssele Site V - Leeghwater - Innovation Plot (Netherlands)	108	20	2	May-16 (2016-2023)	2020	Yes (HP, GS, HS)
Tier 4: application submitted and project on-hold						
Firth of Forth Phase 1 Seagreen Alpha and Bravo, UK	500	1,050	150	Oct-14 (2014-2021)	Unknown – on-hold	Yes (HP)
Inch Cape, UK	510	784	110	Oct-14 (2014-2021)	Unknown – on-hold	Yes (HP)
Neart na Gaoithe, UK	475	448	75	Oct-14 (2014-2021)	Unknown – on-hold	Yes (HP)
Moray Firth Western Development Area	660	750	90	2014 (2014-2021)	Unknown – on-hold	Yes (HP)
Dounreay Tri	785	10	2	2017 (2017-2024)	Unknown – project postponed	Yes (HP)

Name and country of project	Distance from NV	Size (MW)	Maximum number of turbines	Month/year consent authorised/ expected (7yr construction window)	Dates of offshore construction / piling ¹	'Worst-case scenario where potential 7-year consent window overlaps with Norfolk Vanguard construction period ²
Norfolk Vanguard	0	1,800	120-257	2019 (2019-2024)	Construction and piling: 2024 – 2028	Yes
Tier 5: application in preparation						
Norfolk Boreas	30	1,800	257	2019 TBC (2019-2026)	Possible piling: 2025-2029	Yes (HP, GS, HS)
Hornsea Project Three	88	2,400	342	2018 TBC (2018-2025)	Possible piling: 2022-2023 and 2029-2030	Yes (HP, GS, HS)
Thanet Extension	165	340	34	2018 TBC (2018-2025)	2020-2023	Yes (HP, GS, HS)
East Anglia ONE North	30	Up to 800	Up to 67		2026 - 2029	Yes (HP, GS, HS)
East Anglia TWO	45	Up to 900	Up to 75		2025 - 2029	Yes (HP, GS, HS)

¹Piling and offshore construction dates are based on the latest dates and information available.

² Potential worst-case scenarios: projects for which consent has been granted (Tier 3 projects) and proposed piling is likely to overlap with the proposed piling of Norfolk Vanguard.

1.1.1 Potential disturbance of harbour porpoise

3. For the 'worst-case' scenario, based on the 25 UK and European OWFs piling at exactly the same time as Norfolk Vanguard, using concurrent piling with two locations on each OWF site with no overlap in the impact areas, the estimated maximum cumulative impact area is 110,448km², based on a radius of 26km from each piling location, with two piling locations per project with no overlap in impact areas (4,248km² per project). The maximum number of harbour porpoise that could potentially be disturbed is 75,688 individuals, which represents approximately 22% of the North Sea MU reference population (Table 2).
4. The CIA indicates that if all 25 UK and European OWFs were piling at exactly the same time as Norfolk Vanguard, based on a single pile installation, the estimated maximum cumulative impact area is 55,224km² and the maximum number of harbour porpoise that could potentially be disturbed is 37,839 individuals which represents approximately 11% of the North Sea MU reference population (Table 2).
5. It is highly unlikely that all 25 UK and European OWFs ('worst-case' scenario) could be concurrently or single piling at exactly the same time as Norfolk Vanguard. The 'likely overlap' scenario presented in the ES is deemed to be highly conservative and therefore this has been used to define the cumulative disturbance magnitude.

Table 2 Quantified CIA for the potential disturbance of harbour porpoise during single and concurrent piling of UK OWFs for the ‘worst-case’ scenario based on potential overlap of construction periods for Tier 3 consented projects (based on seven years construction window); Tier 4 projects where applications are submitted and potential construction dates are now; and Tier 5 projects where application are known to be in preparation (based on possible construction dates) which could overlap with the construction period at Norfolk Vanguard.

Name of Project	Tier	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km ²)	Potential number of harbour porpoise impacted during single piling (2,124km ²)	Potential number of harbour porpoise impacted during concurrent piling with no overlap (4,248km ²)
Norfolk Vanguard	5	0	O ¹	0.888	1,886	3,772
Creyke Beck A	3	163	O	0.888	1,886	3,772
Creyke Beck B	3	193	O	0.888	1,886	3,772
Teesside A	3	180	N	0.837	1,778	3,556
Sofia	3	175	O ²	0.888	1,886	3,772
East Anglia THREE	3	0	L	0.607	1,289	2,579
Hornsea Project Two	3	125	O	0.888	1,886	3,772
Triton Knoll phase 1-3	3	288	O	0.888	1,886	3,772
Kincardine	3	535	R	0.607	1,289	2,579
Firth of Forth Phase 1 Seagreen Alpha and Bravo,	4	500	R	0.599	1,272	2,545
Inch Cape	4	510	R	0.599	1,272	2,545
Near na Gaoithe	4	475	R	0.599	1,272	2,545
Dounreay Ti	4	785	S	0.152	323	646
Moray Firth Western Development Area	4	660	S	0.152	323	646
Norfolk Boreas	5	30	O ³	0.888	1,886	3,772

Name of Project	Tier	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km ²)	Potential number of harbour porpoise impacted during single piling (2,124km ²)	Potential number of harbour porpoise impacted during concurrent piling with no overlap (4,248km ²)
Hornsea Project THREE	5	80	O	0.888	1,886	3,772
Thanet Extension	5	165	L	0.607	1,289	2,579
East Anglia ONE North	5	30	L	0.607	1,289	2,579
East Anglia TWO	5	45	L	0.607	1,289	2,579
Mermaid	3	125	N	0.837	1,778	3,556
Northwester 2	3	130	N	0.837	1,778	3,556
Delta Nordsee 1	3	300	M	0.277	588	1,177
Delta Nordsee 2 (OWP Delta Nordsee 2)	3	300	M	0.277	588	1,177
Borssele I and II	3	133	N	0.837	1,778	3,556
Borssele III and IV	3	123	N	0.837	1,778	3,556
Borssele Site V - Leeghwater - InNvation Plot	3	108	N	0.837	1,778	3,556
Total					37,839	75,68
% of North Sea MU reference population (345,373 harbour porpoise)					11%	22%

¹NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O; therefore, higher density estimate from survey block O is used.

²Dogger Bank Zone Teesside B overlaps SCANS-III survey block O & N, but majority of site is in block O.

³Norfolk Boreas overlaps SCANS-III survey block O & L; therefore, higher density estimate from survey block O is used.

1.1.2 Potential disturbance of grey and harbour seal

6. For the 'worst-case' scenario, based on all the 19 UK and European OWFs piling at exactly the same time as Norfolk Vanguard, using concurrent piling with two locations on each OWF site with no overlap in the impact areas, the estimated maximum cumulative impact area is 84,960km².
7. The maximum number of grey seal that could potentially be disturbed if all offshore wind farms were concurrently piling at exactly the same time is 2,222 (10% of the reference population). The maximum number of grey seal that could potentially be disturbed if all offshore wind farms were single piling at exactly the same time is 1,111 (5% of the reference population; Table 3).
8. The maximum number of harbour seal that could potentially be disturbed if all offshore wind farms were concurrently piling at exactly the same time is 390 (0.9% of the reference population). The maximum number of harbour seal that could potentially be disturbed if all offshore wind farms were single piling at exactly the same time is 195 (0.5% of the reference population; Table 3).
9. It is highly unlikely that all 25 UK and European OWFs ('worst-case' scenario) could be concurrently or single piling at exactly the same time as Norfolk Vanguard. The 'likely overlap' scenario presented in the ES is deemed to be highly conservative and therefore this has been used to define the cumulative disturbance magnitude.

Table 3 Quantified CIA for the potential disturbance of grey and harbour seal during single and concurrent piling of UK OWFs for the ‘worst-case’ scenario based on potential overlap of construction periods for Tier 3 consented projects (based on seven years construction window); Tier 4 projects where applications are submitted and potential construction dates are now; and Tier 5 projects where application are known to be in preparation (based on possible construction dates) which could overlap with the construction period at Norfolk Vanguard.

Name of Project	Tie r	Distance to NV (km)	Grey seal density estimate (No/km ²) ¹	Harbour seal density estimate (No/km ²) ¹	Potential number of grey seal impacted		Potential number of harbour seal impacted	
					single piling	concurrent piling	single piling	concurrent piling
Norfolk Vanguard	5	0	0.002	0.0001	4.25	8.50	0.21	0.42
Creyke Beck A	3	163	0.05	0.0004	106.20	212.40	0.85	1.70
Creyke Beck B	3	193	0.09	0.001	191.16	382.32	2.12	4.25
Teesside A	3	180	0.01	0.00004	21.24	42.48	0.08	0.17
Sofia	3	175	0.09	0.001	191.16	382.32	2.12	4.25
East Anglia THREE	3	0	0.00009	0.00009	0.19	0.38	0.19	0.38
Hornsea Project Two	3	125	0.08	0.008	169.92	339.84	16.99	33.98
Triton Knoll phase 1-3	3	288	0.08	0.008	169.92	339.84	16.99	33.98
Norfolk Boreas	5	30	0.0006	0.00006	1.27	2.55	0.13	0.25
Hornsea Project THREE	5	80	0.08	0.008	169.92	339.84	16.99	33.98
Thanet Extension	5	165	0.02	0.06	42.48	84.96	127.44	254.88
East Anglia ONE North	5	30	0.0009	0.0006	1.91	3.82	1.27	2.55
East Anglia TWO	5	45	0.01	0.002	21.24	42.48	4.25	8.50
Mermaid	3	125	0.0019	0.0005	4.04	8.07	1.06	2.12
Northwester 2	3	130	0.0019	0.0005	4.04	8.07	1.06	2.12
Delta Nordsee 1	3	300	0.00000002	0.0000	0.00	0.00	0.00	0.00
Delta Nordsee 2 (OWP Delta Nordsee 2)	3	300	0.00000002	0.0000	0.00	0.00	0.00	0.00
Borssele I and II	3	133	0.0019	0.0005	4.04	8.07	1.06	2.12

Name of Project	Tie r	Distance to NV (km)	Grey seal density estimate (No/km ²) ¹	Harbour seal density estimate (No/km ²) ¹	Potential number of grey seal impacted		Potential number of harbour seal impacted	
					single piling	concurrent piling	single piling	concurrent piling
Borssele III and IV	3	123	0.0019	0.0005	4.04	8.07	1.06	2.12
Borssele Site V - Leeghwater - InNvation Plot	3	108	0.0019	0.0005	4.04	8.07	1.06	2.12
Total					1,111	2,222	195	390
% of reference population (22,290 grey seal; 43,161 harbour seal)					5%	10%	0.5%	0.9%

¹The densities included are based on a 26km buffer around the OWF (or grouped OWFs in the case of the Dogger Bank and East Anglia projects), using the 5x5km grid squares of the seals-at-sea total usage data that intersect with the projects and 26km buffer. Based on Russel *et al.* (2017) seals at-sea total usage maps

1.2 Potential Worst Case Scenario with Norfolk Boreas

10. As a highly precautionary approach this assessment includes a further iteration adding Norfolk Boreas to the potential worst-case scenario. The six OWFs that have been included in this assessment are:

- Norfolk Vanguard
- Creyke Beck B
- Sofia
- Hornsea Project 3
- East Anglia TWO

1.2.1 Norfolk Boreas

11. Potential disturbance of harbour porpoise

12. In this scenario, for concurrent piling the estimated maximum area of potential disturbance is 25,488km², without any overlap in the potential areas of disturbance at each wind farm or between wind farms. Therefore, maximum number of harbour porpoise that could potentially be temporarily disturbed is 21,439 individuals, which represents approximately 6% of the North Sea MU reference population (Table 4).

13. Based on a single pile installation at each of the six OWFs, the estimated maximum area of potential disturbance is 12,744km², without any overlap in the potential areas of disturbance at each wind farm or between wind farms. Therefore, the maximum number of harbour porpoise that could potentially be temporarily disturbed is 10,719 individuals which represents approximately 3% of the North Sea MU reference population (Table 4).

Table 4 Quantified in-combination assessment for the potential disturbance of harbour porpoise during single and concurrent piling of OWFs for the potential worst-case scenario including Norfolk Boreas, based on the OWF projects which could be piling at the same time as Norfolk Vanguard.

Name of Project	Tier	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km ²)	Potential number of harbour porpoise disturbed during single piling (2,124km ²)	Potential number of harbour porpoise disturbed during concurrent piling with no overlap (4,248km ²)
Norfolk Vanguard	5	0	O ¹	0.888	1,886	3,772
Dogger Bank Zone Creyke Beck B	3	193	O	0.888	1,886	3,772
Dogger Bank Zone Teesside B now Sofia	3	180	O ²	0.837	1,886	3,772
Hornsea Project THREE	5	80	O	0.888	1,886	3,772
East Anglia TWO	5	45	L	0.607	1,289	2,579
Norfolk Boreas	5	30	O ³	0.888	1,886	3,772
Total					10,719	21,439
% of North Sea MU reference population (345,373 harbour porpoise)					3%	6%

¹NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O; therefore higher density estimate from survey block O is used.

²Dogger Bank Zone Teesside B now Sofia overlaps SCANS-III survey block O & N, but majority of site is in block O.

³Norfolk Boreas overlaps SCANS-III survey block O & L; therefore higher density estimate from survey block O is used.

1.2.2 Potential disturbance of harbour and grey seal

14. In this scenario, for concurrent piling the estimated maximum number of grey seal that could potentially be disturbed is 1,187 (5% of the reference population). The maximum number of grey seal that could potentially be disturbed if all offshore wind farms were single piling at exactly the same time is 594 (3% of the reference population; Table 3).
15. The maximum number of harbour seal that could potentially be disturbed if all offshore wind farms were concurrently piling at exactly the same time is 53 (0.1% of the reference population). The maximum number of harbour seal that could potentially be disturbed if all offshore wind farms were single piling at exactly the same time is 26 (0.06% of the reference population; Table 3).

Table 5 Quantified CIA for the potential disturbance of grey and harbour seal during single and concurrent piling of OWFs for the potential worst-case scenario based on the OWF projects which could be piling at the same time as Norfolk Vanguard.

Name of Project	Tier	Distance to NV (km)	Grey seal density estimate (No/km ²) ¹	Harbour seal density estimate (No/km ²) ¹	Potential number of grey seal disturbed		Potential number of harbour seal disturbed	
					single piling	concurrent piling	single piling	concurrent piling
Norfolk Vanguard	5	0	0.002	0.0001	4	8	0.2	0.4
Creyke Beck B	3	193	0.09	0.001	198	396	3	6
Sofia	3	175	0.09	0.001	198	396	3	6
Hornsea Project THREE	5	80	0.08	0.008	166	331	17	34
East Anglia TWO	5	45	0.01	0.002	27	53	3	6
Norfolk Boreas	5	30	0.0006	0.00006	1	3	0.1	0.3
Total					594	1,187	26	53
% of reference population (22,290 grey seal; 43,161 harbour seal)					3%	5%	0.06%	0.1%

¹The densities included are based on a 26km buffer around the OWF (or grouped OWFs in the case of the Dogger Bank and East Anglia projects), using the 5x5km grid squares of the seals-at-sea total usage data that intersect with the projects and 26km buffer; based on Russell *et al.* (2017).

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