CALEDONIA
Offshore Wind Farm

Code: UKCAL-CWF-CON-EIA-RPT-00007-7B43

Volume 7B Proposed Development (Offshore) Appendices

Appendix 6-5 Migratory Collision Risk Modelling Technical Report
Annex 2 Migratory Collision Risk Modelling Results (Caledonia North)

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Volume 7B Appendix 6-5 Annex 2 Migratory Collision Risk Modelling Results (Caledonia North)

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Acronyms and Abbreviations

mCRM	Migratory Collision Risk Modelling
OWF	Offshore Wind Farm
SD	Standard Deviation
WCS	Worst-case Scenario
WTG	Wind Turbine Generator

1 Introduction

1.1.1.1 The results of the migratory Collision Risk Modelling (mCRM) for the Caledonia Offshore Wind Farm (OWF), specifically the Caledonia North Site, are presented within this annex. Two Wind Turbine Generator (WTG) options have been modelled using the Marine Scotland Avian Migration Collision Risk Model Shiny Application ("mCRM Application"; HiDef Aerial Surveying Ltd., 2024[1]). The full mCRM methodology is outlined in Volume 7B, Appendix 6-5: Migratory Collision Risk Modelling Technical Report.

1.1.1.2 The WTG parameters used within the mCRM for the Caledonia North Site are presented in (Table 1-1). Scoping results are presented in Section 2, and estimated seasonal collisions are presented in Section 3.

Table 1-1: OWF and WTG parameters used for mCRM for the Caledonia North Site.

Parameter	WTG 1 (N)	WTG 2 (N)
Number of WTGs	47	77
Latitude (degrees)	58.26	58.26
Width (km)	29.5	29.5
Number of blades	3	3
Rotor radius (m)	155	118
Blade width (m)	7.5	7.5
Average pitch (º)	2	2
Average pitch SD (º)	No data (assumed 0)	No data (assumed 0)
Rotation speed (rpm)	8.4	8.4
Rotation speed SD (rpm)	No data (assumed 0)	No data (assumed 0)

2 Scoping Results

2.1.1.1 The results from the scoping process (methodology described in Volume 7B, Appendix 6-5: Migratory Collision Risk Modelling Technical Report) are presented in Table 2-1 and Table 2-2. For each table, the species UK Population estimate (and corresponding Standard Deviation (SD)) predicted to intersect the Caledonia North Site on migration, based on the default UK population sizes within the model are presented. The population estimate predicted to intersect the Caledonia North Site is calculated based on the proportion of randomly generated migration lines which intersect the Caledonia North Site within the species defined migratory corridor. Further detail on population estimation can be found within the mCRM Application github repository (HiDef Aerial Surveying Ltd., 2024[1]).

2.1.1.2 The percentage of the UK population predicted to intersect the Caledonia North Site (and thus at potential risk of collision) on migration is also provided within Table 2-1 and Table 2-2. In accordance with the Scoping methodology (described in Volume 7B, Appendix 6-5: Migratory Collision Risk Modelling Technical Report) where less than 1% of the UK population is predicted to intersect the Caledonia North Site, the species has been scoped out of further modelling. The species that have been scoped in have been carried through into Section 3.

Table 2-1: Caledonia North Site scenario WTG 1 initial scoping results.

Species	Population Estimate	SD	% at Collision Risk	Scoped In/Out
Bar-tailed godwit (*Limosa lapponica*)	8,909	1,839	1.30	In
Bean goose (*Anser fabalis*)	18	3	1.80	In
Bittern (*Botaurus stellaris*)	-	-	0.00	Out
Black-tailed godwit (*Limosa limosa*)	-	-	0.00	Out
Black-throated diver (*Gavia arctica*)	21	4	1.70	In
Canadian Light-bellied brent goose (*Branta bernicla hrota*)	-	-	0.00	Out
Common scoter (*Melanitta nigra*)	1,159	271	0.90	Out
Corncrake (*Crex crex*)	192	40	1.10	In
Curlew (*Numenius arquata*)	1,889	312	1.30	In
Dotterel (*Charadrius morinellus*)	8	2	1.90	In
Dunlin (*Calidris alpina*)	23,424	4,535	1.20	In
Eider (*Somateria mollissima*)	1,295	274	1.20	In
Golden plover (Pluvialis apricaria)	39,180	6,977	1.20	In
Goldeneye (*Bucephala clangula*)	489	105	1.30	In
Goosander (*Mergus merganser*)	394	57	2.30	In
Great crested grebe (*Podiceps cristatus*)	-	-	0.00	Out
Great northern diver (*Gavia immer*)	137	28	1.20	In

Species	Population Estimate	SD	% at Collision Risk	Scoped In/Out
Greenshank (*Tringa nebularia*)	82	15	1.10	In
Grey plover (*Pluvialis squatarola*)	1,309	242	1.10	In
Hen harrier (*Circus cyaneus*)	29	6	1.30	In
Icelandic greylag goose (*Anser anser*)	169	73	0.20	Out
Knot (*Calidris canutus*)	3,577	728	1.00	In
Lapwing (*Vanellus vanellus*)	41,594	9,454	1.10	In
Long-tailed duck (*Clangula hyemalis*)	168	30	1.30	In
Mallard (*Anas platyrhynchos*)	12,697	2,491	1.50	In
Marsh harrier (*Circus aeruginosus*)	35	7	1.30	In
Merlin (*Falco columbarius*)	39	13	0.50	Out
Nightjar (*Caprimulgus europaeus*)	67	17	0.90	Out
Osprey (*Pandion haliaetus*)	11	2	1.60	In
Oystercatcher (*Haematopus ostralegus*)	4,085	866	1.10	In
Pink-footed goose (*Anser brachyrhynchus*)	893	426	0.20	Out
Pintail (*Anas acuta*)	219	49	1.00	In
Purple sandpiper (*Calidris maritima*)	310	56	1.30	In
Red-breasted merganser (*Mergus serrator*)	204	39	1.30	In

Species	Population Estimate	SD	% at Collision Risk	Scoped In/Out
Redshank (*Tringa totanus*)	4,110	842	1.00	In
Red-throated diver (*Gavia stellata*)	513	91	1.50	In
Ringed plover (Charadrius hiaticula)	2,767	603	1.00	In
Ruff (*Calidris pugnax*)	375	77	1.20	In
Sanderling (*Calidris alba*)	2,492	522	1.20	In
Scaup (*Aythya marila*)	54	14	0.80	Out
Shelduck (*Tadorna tadorna*)	666	129	1.10	In
Short-eared owl (*Asio flammeus*)	193	38	1.30	In
Shoveler (*Anas clypeata*)	186	48	0.80	Out
Slavonian grebe (*Podiceps auritus*)	12	3	1.20	In
Snipe (*Gallinago gallinago*)	67,278	13,692	1.10	In
Spotted crake (*Porzana porzana*)	1	-	3.80	In
Svalbard barnacle goose (*Branta leucopsis*)	1,175	166	2.70	In
Svalbard light-bellied brent goose (*Branta bernicla hrota*)	230	32	2.30	In
Teal (*Anas crecca*)	338	268	0.10	Out
Tufted duck (*Aythya fuligula*)	1,870	420	1.20	In
Turnstone (*Arenaria interpres*)	4,671	941	1.30	In

Species	Population Estimate	SD	% at Collision Risk	Scoped In/Out
Velvet scoter (*Melanitta fusca*)	40	10	1.10	In
Whimbrel (*Numenius phaeopus*)	53	12	1.10	In
White-tailed eagle (*Haliaeetus albicilla*)	2	1	1.10	In
Whooper swan (*Cygnus cygnus*)	742	115	1.90	In
Wigeon (*Anas penelope*)	5,465	1,257	1.10	In
Wood sandpiper (*Tringa glareola*)	1	-	1.90	In

Table 2-2: Caledonia North Site scenario WTG 2 initial scoping results.

Species	Population Estimate	SD	% at Collision Risk	Scoped In/Out
Bar-tailed godwit	8,905	1,849	1.30	In
Bean goose	18	3	1.80	In
Bittern	-	-	0.00	Out
Black-tailed godwit	-	-	0.00	Out
Black-throated diver	21	4	1.70	In
Canadian light-bellied brent goose	-	-	0.00	Out
Common scoter	1,159	271	0.90	Out
Corncrake	192	41	1.10	In
Curlew	1,889	325	1.30	In
Dotterel	8	2	1.90	In
Dunlin	23,424	4,455	1.20	In
Eider	1,295	278	1.20	In
Golden plover	39,180	7,133	1.20	In
Goldeneye	489	102	1.30	In
Goosander	394	57	2.30	In
Great crested grebe	-	-	0.00	Out
Great northern diver	137	28	1.20	In
Greenshank	82	15	1.10	In
Grey plover	1,309	243	1.10	In
Hen harrier	29	6	1.30	In
Icelandic greylag goose	169	75	0.20	Out
Knot	3,577	730	1.00	In
Lapwing	41,594	9,232	1.10	In
Long-tailed duck	168	30	1.30	In

Species	Population Estimate	SD	% at Collision Risk	Scoped In/Out
Mallard	12,689	2,452	1.50	In
Marsh harrier	35	7	1.30	In
Merlin	39	13	0.50	Out
Nightjar	67	17	0.90	Out
Osprey	11	3	1.60	In
Oystercatcher	4,085	894	1.10	In
Pink-footed Goose	893	427	0.20	Out
Pintail	219	49	1.00	In
Purple sandpiper	310	57	1.30	In
Red-breasted merganser	204	40	1.30	In
Redshank	4,110	853	1.00	In
Red-throated diver	513	91	1.50	In
Ringed plover	2,766	602	1.00	In
Ruff	375	77	1.20	In
Sanderling	2,492	518	1.20	In
Scaup	54	14	0.80	Out
Shelduck	666	129	1.10	In
Short-eared owl	193	38	1.30	In
Shoveler	186	49	0.80	Out
Slavonian grebe	12	3	1.20	In
Snipe	67,248	13,682	1.10	In
Spotted crake	1	-	3.80	In
Svalbard barnacle goose	1,175	167	2.70	In
Svalbard light-bellied brent goose	230	32	2.30	In

Species	Population Estimate	SD	% at Collision Risk	Scoped In/Out
Teal	338	262	0.10	Out
Tufted duck	1,869	412	1.20	In
Turnstone	4,671	938	1.30	In
Velvet scoter	40	10	1.10	In
Whimbrel	53	12	1.10	In
White-tailed Eagle	2	1	1.10	In
Whooper swan	742	113	1.90	In
Wigeon	5,465	1,259	1.10	In
Wood sandpiper	1	-	1.90	In

3 Results

3.1.1.1 The mCRM results for Scenarios 1 and 2 for the Caledonia North Site are presented below in Table 3-1 and Table 3-2. The worst-case scenario (WCS) for the Caledonia North Site, determined by comparing scenarios for the highest estimated annual collision rate, is WTG 2.

Table 3-1: Summary of estimated seasonal migratory collisions for the Caledonia North Site scenario WTG 1.

Species	Pre-breeding	Post-breeding	Other	Total
Bar-tailed godwit	0.131 ± 0.027	0.128 ± 0.026	0 ± 0	0.259 ± 0.037
Bean goose	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Black-throated diver	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Corncrake	0.014 ± 0.003	0.013 ± 0.003	0 ± 0	0.027 ± 0.004
Curlew	0.032 ± 0.006	0.032 ± 0.006	0 ± 0	0.064 ± 0.008
Dotterel	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Dunlin	0.305 ± 0.059	0.301 ± 0.058	0 ± 0	0.606 ± 0.083
Eider	0.082 ± 0.018	0.083 ± 0.018	0 ± 0	0.165 ± 0.025
Golden plover	0.550 ± 0.098	0.541 ± 0.096	0 ± 0	1.091 ± 0.137
Goldeneye	0.110 ± 0.025	0.110 ± 0.025	0 ± 0	0.220 ± 0.035
Goosander	0.095 ± 0.015	0.093 ± 0.014	0 ± 0	0.188 ± 0.021
Great northern diver	0.003 ± 0.001	0.003 ± 0.001	0 ± 0	0.006 ± 0.001
Greenshank	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
Grey plover	0.018 ± 0.003	0.018 ± 0.003	0 ± 0	0.036 ± 0.004
Hen harrier	0.003 ± 0.001	0.003 ± 0.001	0 ± 0	0.006 ± 0.001
Knot	0.046 ± 0.009	0.046 ± 0.009	0 ± 0	0.092 ± 0.013
Lapwing	0.631 ± 0.141	0.640 ± 0.143	0 ± 0	1.271 ± 0.201
Long-tailed duck	0.037 ± 0.007	0.037 ± 0.007	0 ± 0	0.074 ± 0.010
Mallard	3.158 ± 0.649	3.218 ± 0.661	3.261 ± 0.67	9.637 ± 1.143
Marsh harrier	0.002 ± 0	0.002 ± 0	0 ± 0	0.004 ± 0
Osprey	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
Oystercatcher	0.069 ± 0.015	0.067 ± 0.015	0 ± 0	0.136 ± 0.021
Pintail	0.051 ± 0.011	0.051 ± 0.012	0 ± 0	0.102 ± 0.016
Purple sandpiper	0.004 ± 0.001	0.004 ± 0.001	0 ± 0	0.008 ± 0.001

Species	Pre-breeding	Post-breeding	Other	Total
Red-breasted merganser	0.045 ± 0.009	0.047 ± 0.009	0 ± 0	0.092 ± 0.013
Redshank	0.059 ± 0.013	0.058 ± 0.013	0 ± 0	0.117 ± 0.018
Red-throated diver	0.011 ± 0.002	0.01 ± 0.002	0 ± 0	0.021 ± 0.003
Ringed plover	0.036 ± 0.008	0.036 ± 0.008	0 ± 0	0.072 ± 0.011
Ruff	0.005 ± 0.001	0.005 ± 0.001	0 ± 0	0.010 ± 0.001
Sanderling	0.031 ± 0.007	0.031 ± 0.007	0 ± 0	0.062 ± 0.010
Shelduck	0.086 ± 0.019	0.081 ± 0.018	0.084 ± 0.018	0.251 ± 0.032
Short-eared owl	0.017 ± 0.004	0.017 ± 0.004	0 ± 0	0.034 ± 0.006
Slavonian grebe	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
Snipe	0.911 ± 0.181	0.907 ± 0.18	0.933 ± 0.185	2.751 ± 0.315
Spotted crake	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Svalbard barnacle goose	0.020 ± 0.003	0.020 ± 0.003	0 ± 0	0.040 ± 0.004
Svalbard light-bellied brent goose	0.002 ± 0.001	0.002 ± 0.001	0 ± 0	0.004 ± 0.001
Tufted duck	0.400 ± 0.09	0.408 ± 0.092	0 ± 0	0.808 ± 0.129
Turnstone	0.072 ± 0.02	0.070 ± 0.019	0 ± 0	0.142 ± 0.028
Velvet scoter	0.009 ± 0.002	0.009 ± 0.002	0 ± 0	0.018 ± 0.003
Whimbrel	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
White-tailed eagle	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
Whooper swan	0.116 ± 0.027	0.116 ± 0.027	0 ± 0	0.232 ± 0.038
Wigeon	1.265 ± 0.295	1.261 ± 0.294	0 ± 0	2.526 ± 0.416
Wood sandpiper	0 ± 0	0 ± 0	0 ± 0	0 ± 0

Table 3-2: Summary of estimated seasonal migratory collisions for the Caledonia North Site Scenario WTG 2 (WCS).

Species	Pre-breeding	Post-breeding	Other	Total
Bar-tailed godwit	0.204 ± 0.042	0.200 ± 0.041	0 ± 0	0.404 ± 0.059
Bean goose	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
Black-throated diver	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
Corncrake	0.021 ± 0.005	0.021 ± 0.004	0 ± 0	0.042 ± 0.006
Curlew	0.049 ± 0.009	0.048 ± 0.009	0 ± 0	0.097 ± 0.013
Dotterel	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Dunlin	0.485 ± 0.092	0.477 ± 0.09	0 ± 0	0.962 ± 0.129
Eider	0.124 ± 0.027	0.126 ± 0.027	0 ± 0	0.250 ± 0.038
Golden plover	0.866 ± 0.156	0.85 ± 0.154	0 ± 0	1.716 ± 0.219
Goldeneye	0.170 ± 0.037	0.170 ± 0.037	0 ± 0	0.34 ± 0.052
Goosander	0.145 ± 0.022	0.142 ± 0.022	0 ± 0	0.287 ± 0.031
Great northern diver	0.005 ± 0.001	0.005 ± 0.001	0 ± 0	0.010 ± 0.001
Greenshank	0.002 ± 0	0.002 ± 0	0 ± 0	0.004 ± 0
Grey plover	0.029 ± 0.005	0.028 ± 0.005	0 ± 0	0.057 ± 0.007
Hen harrier	0.004 ± 0.001	0.004 ± 0.001	0 ± 0	0.008 ± 0.001
Knot	0.074 ± 0.015	0.073 ± 0.015	0 ± 0	0.147 ± 0.021
Lapwing	0.979 ± 0.213	0.992 ± 0.216	0 ± 0	1.971 ± 0.303
Long-tailed duck	0.058 ± 0.011	0.058 ± 0.011	0 ± 0	0.116 ± 0.016
Mallard	4.768 ± 0.957	4.858 ± 0.975	4.924 ± 0.989	14.55 ± 1.687
Marsh harrier	0.002 ± 0	0.002 ± 0	0 ± 0	0.004 ± 0
Osprey	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
Oystercatcher	0.104 ± 0.023	0.102 ± 0.022	0 ± 0	0.206 ± 0.032
Pintail	0.078 ± 0.018	0.078 ± 0.018	0 ± 0	0.156 ± 0.025
Purple sandpiper	0.007 ± 0.001	0.007 ± 0.001	0 ± 0	0.014 ± 0.001

Species	Pre-breeding	Post-breeding	Other	Total
Red-breasted merganser	0.070 ± 0.014	0.072 ± 0.015	0 ± 0	0.142 ± 0.021
Redshank	0.092 ± 0.02	0.090 ± 0.019	0 ± 0	0.182 ± 0.028
Red-throated diver	0.016 ± 0.003	0.016 ± 0.003	0 ± 0	0.032 ± 0.004
Ringed plover	0.058 ± 0.012	0.058 ± 0.012	0 ± 0	0.116 ± 0.017
Ruff	0.008 ± 0.002	0.008 ± 0.002	0 ± 0	0.016 ± 0.003
Sanderling	0.050 ± 0.01	0.050 ± 0.01	0 ± 0	0.100 ± 0.014
Shelduck	0.130 ± 0.027	0.123 ± 0.026	0.128 ± 0.027	0.381 ± 0.046
Short-eared owl	0.025 ± 0.005	0.025 ± 0.005	0 ± 0	0.050 ± 0.007
Slavonian grebe	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
Snipe	1.432 ± 0.283	1.426 ± 0.282	1.467 ± 0.290	4.325 ± 0.494
Spotted crake	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Svalbard barnacle goose	0.031 ± 0.005	0.031 ± 0.005	0 ± 0	0.062 ± 0.007
Svalbard light-bellied brent goose	0.003 ± 0.001	0.003 ± 0.001	0 ± 0	0.006 ± 0.001
Tufted duck	0.623 ± 0.138	0.634 ± 0.14	0 ± 0	1.257 ± 0.197
Turnstone	0.111 ± 0.028	0.107 ± 0.027	0 ± 0	0.218 ± 0.039
Velvet scoter	0.014 ± 0.004	0.014 ± 0.004	0 ± 0	0.028 ± 0.006
Whimbrel	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
White-tailed eagle	0.001 ± 0	0.001 ± 0	0 ± 0	0.002 ± 0
Whooper swan	0.166 ± 0.035	0.167 ± 0.036	0 ± 0	0.333 ± 0.05
Wigeon	1.949 ± 0.453	1.943 ± 0.451	0 ± 0	3.892 ± 0.639
Wood sandpiper	0 ± 0	0 ± 0	0 ± 0	0 ± 0

4 References

[1] HiDef Aerial Surveying Ltd. (2024) 'mCRM: Avian Migration Collision Risk Model'. R package version f0.4.1. Available at: https://hidef-aerial-surveying.github.io/mCRM/ (Accessed 13/05/2024)

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