Testing the CEAF modelling tool on three SEANSE scenarios: collision mortality and displacement of four seabird species

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Preface

Within the framework of the EU co-financed project *Strategic Environmental Assessment North Sea Energy* (SEANSE), countries around the North Sea are testing a modelling tool, jointly developed within the so-called *Common Environmental Assessment Framework* (CEAF), which aims to quantify the cumulative effects of offshore wind farms. In order to test this modelling tool, Rijkswaterstaat has commissioned Bureau Waardenburg to calculate the cumulative effects of collision mortality and displacement on four bird species in offshore wind farms in the southern North Sea for three different development scenarios.

The authors thank everyone who has contributed to this report, especially Ruben Fijn (Bureau Waardenburg) who carried out the internal quality assurance and Rob Gerits (Rijkswaterstaat) who coordinated the project and together with Maarten Platteeuw (Rijkswaterstaat) commented on previous versions of this report.

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1 Introduction

Within the framework of the Political Declaration on Energy Cooperation between the North Seas countries, it has been agreed to develop a modelling tool to quantify the cumulative effects of offshore wind farms, which can be used in environmental impact assessments and development plans for offshore wind farms. On the basis of this collaboration, the European Union co-financed project *Strategic Environmental Assessment North Sea Energy* (SEANSE) has been initiated, in which countries around the North Sea are testing this modelling tool within the so-called *Common Environmental Assessment Framework* (CEAF). The Dutch Rijkswaterstaat (RWS) and the German Federal Maritime and Hydrographic Agency (BSH) are in charge of the accomplishment of these tests.

In order to test the modelling tool, RWS commissioned Bureau Waardenburg to calculate the cumulative collision mortality and displacement numbers of four seabird species in three scenarios based on methods/models defined within the CEAF Guidance. Specifically, these calculations aim to quantify the impact of collisions on black-legged kittiwake (*Rissa tridactyla*) and lesser black-backed gull (*Larus fuscus*), as well as the impact of displacement on the red-throated diver (*Gavia stellata*) and common guillemot (*Uria aalge*).

The calculations are performed on three scenarios for offshore wind farm development, which are formulated as follows:

- Scenario 1; including wind farms expected to be in operation by 2023.
- Scenario 2; including wind farms expected to be in operation by 2030.
- Scenario 3; including wind farm developments expected to take place after 2030, as far as already identified by the governments of the participating countries.

The starting point of the calculations in this study is the Dutch programme Kader Ecologie and Cumulatie (KEC), where expected numbers of bird victims were modelled for offshore wind farms in the southern North Sea expected to be in operation by 2023 (Rijkswaterstaat 2015). Recently, these calculations were actualised with information from the Dutch Road Map 2030 programme, referring to wind farm developments until 2030. This resulted in several reports within the project named KEC 3.0 (Van der Wal *et al.* 2018, Gyimesi *et al.* 2018, Rijkswaterstaat 2019).

In this study, we mainly follow the same methods as the KEC 3.0 studies to calculate the impact of collisions and displacement. However, they deviate from the KEC 3.0 studies in several aspects. Collision mortality is calculated for different variants of bird parameters. One variant is equal to the KEC 3.0 studies, while the others are based on recent empirical data on flight speed and avoidance rate from the ORJIP studies (Skov *et al.* 2018). In the displacement calculations we assume larger buffer ranges around wind farms in comparison with the KEC 3.0 studies, based on recent insights on displacement sensitivity (Dierschke *et al.* 2016, Heinänen & Skov 2018). Also, we present the cumulative effects of collision and displacement in a slightly different way than in the KEC 3.0 studies. The numbers are presented separately for six bimonthly periods, rather than presenting annual cumulative mortality numbers, as summing bimonthly numbers potentially leads to an overestimation of annual casualty numbers (Gyimesi *et al.* 2018). Furthermore, in the KEC 3.0 studies, an arbitrary mortality rate of 10% was assumed as a consequence of displacement, due to the current lack of more realistic data. In this study, the impact of displacement is therefore expressed as the number of displaced individuals, without making an assumption on the mortality rate of these displaced individuals.

2 Scenarios

This study reports calculations on the cumulative collision and mortality displacement incidence (in number of displaced individuals) of four seabird species for three different scenarios of offshore wind farm developments in the southern North Sea. The scenarios, formulated to approach realistic planning of wind farm developments in time and place, are as follows:

- Scenario 1; including wind farms expected to be in operation by 2023.
- Scenario 2; including wind farms expected to be in operation by 2030.
- Scenario 3; including wind farm developments expected to take place after 2030, as far as already identified by the governments of the participating countries.

A comprehensive list of the wind farms included in each scenario with their specifications is given in Appendix A. Table 2.1 provides a summarizing list of the 112 different offshore wind farms in six countries around the North Sea. The combined capacity of these wind farms is estimated to be nearly 75 gigawatt (GW) after 2030 (Table 2.2). Note that information about wind farm developments after 2030 in most North Sea countries is incomplete or not yet available, and hence for scenario 3 we only used currently known wind farms developments in Germany and the Netherlands.

Table 2.1 The number of wind farms per country in each scenario. Note that the scenarios are cumulative, meaning that scenario 2 and scenario 3 may also include wind farms from the previous scenario. Between brackets the number of newly included wind farms is given.

country	scenario 1	scenario 2	scenario 3
Belgium	8	11 (3)	11 (0)
Denmark	2	3 (1)	3 (0)
France	0	1 (1)	1 (0)
Germany	27	39 (12)	46 (7)
Netherlands	9	16 (7)	18 (2)
United Kingdom	23	33 (10)	33 (0)
	69	***103 (34)***	***112 (9)***

Table 2.2 The additional capacity (in megawatt MW) of offshore wind farms per country per scenario. Each cell indicates the summed capacity of added wind farms.

country	scenario 1	scenario 2	scenario 3	total
Belgium	2,101	2,100	0	***4,201***
Denmark	744	800	0	***1,544***
France	0	750	0	***750***
Germany	7,139	5,700	10,950	***23,789***
Netherlands	4,725	7,180	4,000	***15,905***
United Kingdom	13,582	13,600	0	***27,182***
	28,291	***30,130***	***14,950***	***73,371***

3 Methods

The main aim of this study was (apart from contributing to the development of the cumulation modelling tool) to test whether the tool would be able to provide reliable and reproducible data on the cumulative collision mortality of black-legged kittiwake and lesser black-backed gull, as well as the cumulative number of displaced individuals of red-throated diver and common guillemot, for three different scenarios for offshore wind farm developments.

Below we outline the underlying methods of the collision calculations (§3.2) and the displacement calculations (§3.3). Both methods use distribution data originating from ESAS/MWLT monitoring programmes as main input (§3.1).

3.1 Distribution data

Collision mortality and displacement numbers were calculated on the basis of the local density of each species in each wind farm. These densities were determined based on counts performed from ships and/or aircrafts, as part of the large-scale international ESAS (European Seabirds At Sea) and the Dutch MWTL monitoring programmes (see details below). In this study, ESAS monitoring results from the period 1991-2014 were used, together with MWTL data from the period 1991-2017.

In accordance with the first iteration of the KEC (Rijkswaterstaat 2015), large concentrations of black-legged kittiwake and lesser black-backed gull behind fishing vessels were redistributed in space over an area of 55 x 55 km, in order to correct for locally unnaturally high densities and thus to improve the reliability of the analyses. Namely, such aggregations of birds will not occur in wind farms without the presence of fishing vessels. For red-throated diver and guillemot there was no need for such a correction, as they do not follow fishing vessels.

Based on the resulting database, the Dutch Wageningen Marine Research (WMR) determined bimonthly densities in a grid of 5 x 5 km by interpolating the count data (Van der Wal *et al.* 2018). A long-term average over the whole study period (*i.e.* 1991-2017) was calculated for each bimonthly period and for each grid cell to create density maps per species. Subsequently, the layouts of wind farms were laid over these density maps. The local density of each species in each wind farm was calculated from each grid cell overlapping with the wind farm layout[1]. In the case of displacement mortality, the assumption was made that wind farms have a certain buffer around its perimeter up to which they affect birds. Therefore, for these effect estimates average bird densities were calculated for the wind farm footage area plus this buffer, to represent the total disturbed area of the wind farm. Based on the disturbance sensitivity of red-throated

[1] An exception was made for wind farm Dunkerque, as only one 5 x 5 grid-cell partly overlapped with the layout of Dunkerque, meaning that just a slight part of the footage area was covered by available density data. Therefore, three adjacent grid-cells (within 2.5 km from the wind farm) were also taken into account.

diver and common guillemot a buffer of 5.5 km and 2 km respectively around the perimeter of the wind farm was used in the calculations (cf. Dierschke *et al.* 2016, Heinänen & Skov 2018).

3.2 Collision numbers

The numbers of collision victims for black-legged kittiwake and lesser black-backed gull were calculated using the extended SOSS Band model (Band 2012; hereafter the 'Band model'). The basic input parameter for the Band model is the wind farm-specific flux of birds flying through a given rotor swept area. This flux of flying birds was based on the local density of both species in each wind farm. However, the ESAS methodology that was used to collect the density data leads to a tendency to underestimate the number of flying birds. Therefore, the total density (i.e. both sitting and flying) of birds in each wind farm in each bimonthly period was used and multiplied by a correction factor. This factor is the fraction of the total time budget during which the bird is in the air. The correction factor as determined by Garthe & Hüppop (2004) was used for black-legged kittiwake, and the factor as determined by Gyimesi *et al.* (2017) was used for the lesser black-backed gull (respectively 0.6 and 0.4, see Table 3.1).

These densities are stated as fluxes at rotor height on the basis of species-specific flight height distributions and turbine specifications (*i.e.* hub height and rotor diameter). Turbine specifications are discussed in §3.2.2. For flight height distribution we used in the case of the black-legged kittiwake the data provided by Johnston *et al.* (2014), who published modelled flight height distributions based on data of visual observations and radar surveys collected in 32 potential offshore wind farm locations on flight heights of different species of seabirds. The flight height distribution of lesser black-backed gull was calculated on the basis of GPS logger measurements on 130 birds in the Netherlands, Belgium and England (Gyimesi *et al.* 2017).

The Band model further requires several input parameters related to the characteristics of the bird species (§3.2.1) and the wind turbines (§3.2.2) to calculate the theoretical collision risk of each species per type of wind turbine. For each bimonthly period, the calculated species-specific collision risk was multiplied by the species-specific bird flux through the total rotor-swept area of each wind farm, and adjusted for species-specific avoidance behaviour. The estimated number of collision victims per wind farm and per bird species was subsequently calculated for every two months. Contrary to the KEC 3.0 studies (Rijkswaterstaat 2019), these bimonthly numbers were not totalled to get a yearly estimate of the number of collisions, as this may lead to an overestimation. As the calculations are based on bimonthly counts, these may comprise of double counts of birds that stay longer in a certain area than two months. Therefore, these birds may theoretically die more than once in the model. The decision was thus made to merely present bimonthly mortality numbers.

3.2.1 Bird-related data

Collision mortality in each bimonthly period was calculated for four different variants, each using a different combination of flight speed and avoidance rate of black-legged kittiwake and lesser black-backed gull.

Table 3.1 provides a summary of all bird-related parameter values used in the Band model calculations, whereas Table 3.2 summarizes which values for flight speed and avoidance were used in each variant.

Body length (m) and wingspan (m) are based on Snow & Perrins (1998), where we used the midpoint value in case a range of values was stated. For black-legged kittiwake, flight speed (m/s) was based on a publication of Alerstam *et al.* (2007) or on an empirical study by Skov *et al.* (2018), and nocturnal activity and fraction of time flying followed the assumptions of Garthe & Hüppop (2004). The collision risk of black-legged kittiwake was calculated using the flight height distribution determined by Johnston *et al.* (2014). For lesser black-backed gull, data on flight heights, nocturnal activity and fraction of time flying were obtained from GPS tag measurements on birds in Dutch, Belgian, and British colonies around the southern North Sea (Gyimesi *et al.* 2017). Flight speed of lesser black-backed gull was either based on Gyimesi *et al.* (2017) or on Skov *et al.* (2018).

The flux of each species through the total rotor-swept area of a wind farm, multiplied by the collision risk of each species, resulted in the number of collisions without avoidance. Therefore, we corrected these numbers with species-specific avoidance values (micro- and macro avoidance incorporated in one value). These values were either obtained from a review of Maclean *et al.* (2009), in which they advised to use an avoidance percentage of 99.5% for gulls, or from Skov *et al.* (2018) in which a slightly larger avoidance rate of 99.8% was suggested.

Table 3.1 Parameter values per bird species used in the extended Band model (Band 2012).

	black-legged kittiwake	**lesser black-backed gull**
Body length (m)[1]	0.39	0.58
Wingspan (m)[1]	1.075	1.425
Flight speed (m/s)	13.1[2] / 6.22[3]	9.41[4] / 8.10[3]
Nocturnal activity	0.5[5]	0.4275[4]
Fraction time flying	0.6[5]	0.4[4]
Avoidance (%)	99.5[6] / 99.8[3]	99.5[6] / 99.8[3]

[1] Snow & Perrins 1998 [3] Skov *et al.* 2018 [5] Garthe & Hüppop 2004
[2] Alerstam *et al.* 2007 [4] Gyimesi *et al.* 2017 [6] Maclean *et al.* 2009

Table 3.2 Parameter values for flight speed (m/s) and avoidance (%) used in the four different variants. Variant 1 uses parameter values equal to the KEC studies. Variant 2 uses flight speed from the ORJIP studies and avoidance rate equal to KEC. In variant 3, flight speed equal to the KEC studies and avoidance from ORJIP is used. In variant 4, both parameter values come from the ORJIP studies. See Table 3.1 for the literature references.

	black-legged kittiwake		**lesser black-backed gull**	
	flight speed (m/s)	avoidance (%)	flight speed (m/s)	avoidance (%)
variant 1	13.1	99.5	9.41	99.5
variant 2	6.22	99.5	8.10	99.5
variant 3	13.1	99.8	9.41	99.8
variant 4	6.22	99.8	8.10	99.8

3.2.2 Wind farm related data

A comprehensive list of the wind farms included in each scenario with their specifications, as delivered by RWS, is given in Appendix A and already described in Chapter 2.

Table 3.3 provides per wind turbine capacity (in megawatt (MW)) a summary of the turbine characteristics used in the Band model calculations. Each wind farm is assumed to have turbines installed of a specific capacity (see Appendix A). The wind farms in scenario 3 are assumed to have wind turbines with a capacity of 15 MW. The parameter values of these 15 MW turbines slightly deviate from the 15 MW turbines used in the KEC 3.0 studies (see last row, Table 3.3). For these turbines, the commissioner delivered hub height and rotor diameter, while rotation speed, maximum blade width and pitch were extrapolated from known parameters of existing turbines (cf. Gyimesi *et al.* 2018).

Table 3.3 *Parameters used for the different turbine power ratings. All calculations are based on triple-blade turbines. Adjusted from Gyimesi* et al. *(2018). *Hub height and rotor diameter adjusted for scenario 3 wind farms. MW = megawatt, rpm = rotations per minute, m = meter, º = angle of rotor blades.*

capacity (MW)	**speed (rpm)**	**rotor diameter (m)**	**hub height (m)**	**blade width (m)**	**blade pitch (°)**
2	19.11	80	40	3.5	6.1
2.3	16.03	93	46.5	3.3	6.1
3	15.31	100	50	3.5	6
3.3	14.85	112	56	3.6	6.0
3.6	13.06	120	60	3.7	5.9
4	13.94	116	58	3.8	5.9
5	12.96	129	64.5	4.0	5.7
6	12.22	142	71	4.3	5.6
7	11.62	153	76.5	4.6	5.4
8	12.12	164	82	4.9	5.3
8.4	10.95	164	111.5	5.0	5.2
9	10.70	174	87	5.1	5.1
9.5	10.52	164	105	5.3	5.1
10	10.00	221	110.5	5.4	5.0
12	9.75	220	145	5.9	4.7
15	9.06	232	142	6.8	4.3
15*	9.06	250	175	6.8	4.3

3.3 Numbers of individuals displaced

The numbers of red-throated diver and common guillemot affected by offshore wind farms through displacement are calculated for each bimonthly period by multiplying the area of the footprint of the wind farms with the local density of the species in this area (see §3.1) and a scale factor for wind farm area sizes. We assumed that 100% of the birds within the footprint of a wind farm were displaced.

In some cases, search areas for (future) offshore wind farm development are (much) larger than the actual size of the wind farm will be when the wind farm is operational. Therefore, in accordance with Van der Wal *et al.* (2018), the number of affected birds was multiplied with a scale-factor. For future wind farms, this scale-factor was defined as the proportion between the search area and the estimated area. This estimated area was calculated based on the total capacity of the wind farm and assuming an average realised capacity of 6 MW per km^2. For operational wind farms or wind farms under construction, we assumed a scale-factor of 1, unless we had indications that the calculated wind farm areas (based on delivered GIS shapefiles) were deviating from the actual area of the wind farm. In such cases, we calculated the scale-factor as done for future wind farms. Appendix A lists the scale-factors used for all wind farms.

Comparable to the collision mortality, summing the bimonthly numbers may lead to an overestimation. Therefore, displacement numbers were neither totalled to a yearly estimate of displaced individuals, but merely presented for each bimonthly period.

4 Results

Below we present a summary of the calculations of collision mortality (§4.1) and displacement numbers (§4.2) for the three scenarios of the SEANSE approach.

4.1 Collision mortality

4.1.1 Lesser black-backed gull

The largest cumulative number of collision victims of lesser black-backed gulls is calculated in the period June/July when using the parameter values of variant 1, with respectively 168, 278 and 298 victims per year in scenario 1, 2 and 3 (Table 4.1a). Generally in each variant, the numbers of victims steadily increase from the period February/March to June/July, after which they steadily decrease until October/November. Substantially less lesser black-backed gull collide with offshore wind turbines in the period December/January than in other periods of the year, which is a consequence of the fact that most lesser black-backed gull do not winter in the southern North Sea.

The use of a larger avoidance rate or lower flight speed (in accordance with Skov *et al.* 2018) compared to using the parameters values of variant 1 as in Rijkswaterstaat (2019) generally resulted in less collision victims. This decrease was substantially stronger for avoidance rate (variant 3, Table 4.1c) than for flight speed (variant 2, Table 4.1b). The combined effect of using both parameter values of Skov *et al.* (2018) in variant 4 resulted in the lowest number of victims (Table 4.1d).

The relative share per country in the total collision numbers varies between periods. Most victims in the periods October/November and December/January are attributed to Belgian wind farms, while the United Kingdom has the largest share in the total number of victims in February/March, the Netherlands in the periods April/May and June/July, and German wind farms in the period August/September.

In absolute numbers, the wind farms added in scenario 1 generated most victims of lesser black-backed gull (with the exception of the period October/November), although the total capacity of wind farms in scenario 1 is slightly less than the total capacity of wind farms in scenario 2 (28,542 MW vs. 30,130 MW; Table 2.2). This implies that the relative impact per MW of wind farms expected to be built after 2023 (i.e. those added in scenario 2 or 3) is generally lower than the relative impact per MW of wind farms in scenario 1.

The collision numbers of lesser black-backed gulls in each separate wind farm for each variant are given in Appendix B.

Table 4.1a The yearly number of collision victims of ***lesser black-backed gull*** *per country and per scenario for each of the bimonthly periods in the ESAS/MWTL database. The numbers are calculated with 4.1a) variant 1: flight speed and avoidance rate as used in Rijkswaterstaat (2019), 4.1b) variant 2: flight speed as found in Skov* et al. *(2018) and avoidance rate as used in Rijkswaterstaat (2019), 4.1c) variant 3: flight speed as used in Rijkswaterstaat (2019) and avoidance rate as found in Skov* et al. *(2018), and 4.1d) variant 4: flight speed and avoidance rate as found in Skov* et al. *(2018). Note that the presented numbers per scenario are cumulative, which means that they also include wind farms from the previous scenario(s). Also note that the total summed numbers below each column are calculated using the exact (unrounded) numbers, therefore these totals may slightly deviate from the sum of the presented (rounded) numbers in each column.*

	Dec/Jan			**Feb/Mar**			**Apr/May**		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	6	9	9	10	13	13	30	38	38
Denmark	0	0	0	2	4	4	2	5	5
France	0	1	1	0	1	1	0	3	3
Germany	2	2	2	19	24	28	33	47	53
Netherlands	3	3	4	23	35	40	47	89	98
United Kingdom	2	3	3	32	46	46	32	74	74
	13	***19***	***19***	***86***	***123***	***132***	***143***	***256***	***270***

	Jun/Jul			**Aug/Sep**			**Oct/Nov**		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	24	33	33	14	22	22	26	67	67
Denmark	19	22	22	2	3	3	0	0	0
France	0	5	5	0	3	3	0	3	3
Germany	35	50	60	50	66	72	12	15	15
Netherlands	61	103	113	38	54	59	14	31	32
United Kingdom	29	65	65	30	61	61	16	25	25
	168	***278***	***298***	***135***	***208***	***219***	***68***	***140***	***141***

Table 4.1b variant 2

	Dec/Jan			Feb/Mar			Apr/May		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	5	8	8	9	12	12	28	35	35
Denmark	0	0	0	2	4	4	2	5	5
France	0	1	1	0	1	1	0	3	3
Germany	2	2	2	18	23	27	31	44	50
Netherlands	3	3	3	21	33	37	44	84	92
United Kingdom	2	3	3	30	44	44	30	69	69
	13	***18***	***18***	***81***	***116***	***124***	***134***	***241***	***255***
	Jun/Jul			**Aug/Sep**			**Oct/Nov**		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	22	31	31	13	20	20	25	62	62
Denmark	18	21	21	2	3	3	0	0	0
France	0	4	4	0	2	2	0	2	2
Germany	33	47	56	47	62	68	11	14	14
Netherlands	57	98	106	36	51	55	13	29	30
United Kingdom	27	62	62	28	57	57	15	23	23
	158	***262***	***281***	***127***	***195***	***206***	***64***	***132***	***133***

Table 4.1c variant 3

	Dec/Jan			Feb/Mar			Apr/May		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	2	3	3	4	5	5	12	15	15
Denmark	0	0	0	1	2	2	1	2	2
France	0	0	0	0	0	0	0	1	1
Germany	1	1	1	8	10	11	13	19	21
Netherlands	1	1	1	9	14	16	19	36	39
United Kingdom	1	1	1	13	18	18	13	29	29
	5	***8***	***8***	***34***	***49***	***53***	***57***	***102***	***108***
	Jun/Jul			**Aug/Sep**			**Oct/Nov**		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	9	13	13	6	9	9	11	27	27
Denmark	7	9	9	1	1	1	0	0	0
France	0	2	2	0	1	1	0	1	1
Germany	14	20	24	20	26	29	5	6	6
Netherlands	24	41	45	15	22	24	6	12	13
United Kingdom	12	26	26	12	24	24	6	10	10
	67	***111***	***119***	***54***	***83***	***88***	***27***	***56***	***56***

Table 4.1d variant 4

	Dec/Jan			Feb/Mar			Apr/May		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	2	3	3	4	5	5	11	14	14
Denmark	0	0	0	1	2	2	1	2	2
France	0	0	0	0	0	0	0	1	1
Germany	1	1	1	7	9	11	12	18	20
Netherlands	1	1	1	8	13	15	17	34	37
United Kingdom	1	1	1	12	17	17	12	28	28
	5	***7***	***7***	***32***	***46***	***50***	***54***	***96***	***102***
	Jun/Jul			**Aug/Sep**			**Oct/Nov**		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	9	12	12	5	8	8	10	25	25
Denmark	7	8	8	1	1	1	0	0	0
France	0	2	2	0	1	1	0	1	1
Germany	13	19	23	19	25	27	4	6	6
Netherlands	23	39	43	14	20	22	5	12	12
United Kingdom	11	25	25	11	23	23	6	9	9
	63	***105***	***112***	***51***	***78***	***82***	***26***	***53***	***53***

4.1.2 Black-legged kittiwake

The largest cumulative number of collision victims of black-legged kittiwakes is calculated in the period December/January when using the parameter values of variant 1, with respectively 34, 47 and 49 victims per year in scenario 1, 2 and 3 (Table 4.2a). In the period October/November the collisions numbers are slightly lower with maximally 27, 41 and 41 victims per year in scenario 1, 2 and 3 respectively. In the other periods of the year the lowest numbers of collision victims are expected.

Comparably to the lesser black-backed gull, the use of a larger avoidance rate or lower flight speed (in accordance with Skov *et al.* 2018) compared to using the parameters values of variant 1 as in Rijkswaterstaat (2019) generally resulted in less collision victims. Again, this decrease was substantially stronger for avoidance rate (variant 3, Table 4.2c) than for flight speed (variant 2, Table 4.2b). The combined effect of using both parameter values of Skov *et al.* (2018) in variant 4 resulted in the lowest number of victims (Table 4.2d).

Generally most black-legged kittiwakes become victim in wind farms in the United Kingdom. Only in February/March wind farms in the Netherlands contribute to slightly more victims than wind farms in the United Kingdom. Comparably to the lesser black-backed gull, also for black-legged kittiwakes the wind farms added in scenario 1 generated most victims in absolute numbers.

The collision numbers of black-legged kittiwakes in each separate wind farm for each combination of parameter values are given in Appendix C.

Table 4.2a *The yearly number of collision victims of **black-legged kittiwake** per country and per scenario for each of the bimonthly periods in the ESAS/MWTL database. The numbers are calculated with 4.2a) variant 1: flight speed and avoidance rate as used in Rijkswaterstaat (2019), 4.2b) variant 2: flight speed as found in Skov* et al. *(2018) and avoidance rate as used in Rijkswaterstaat (2019), 4.2c) variant 3: flight speed as used in Rijkswaterstaat (2019) and avoidance rate as found in Skov* et al. *(2018), and 4.2d) variant 4: flight speed and avoidance rate as found in Skov* et al. *(2018). Note that the presented numbers per scenario are cumulative, which means that they also include wind farms from the previous scenario(s). Also note that the total summed numbers below each column are calculated using the exact (unrounded) numbers, therefore these totals may slightly deviate from the sum of the presented (rounded) numbers in each column.*

	Dec/Jan			**Feb/Mar**			**Apr/May**		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	3	4	4	1	2	2	1	2	2
Denmark	1	1	1	0	1	1	0	0	0
France	0	0	0	0	0	0	0	0	0
Germany	8	9	10	4	5	5	3	4	4
Netherlands	7	9	10	6	8	8	2	4	5
United Kingdom	15	23	23	4	7	7	8	13	13
	34	***47***	***49***	***15***	***22***	***22***	***15***	***23***	***24***

	Jun/Jul			**Aug/Sep**			**Oct/Nov**		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	0	0	0	2	2	2	3	3	3
Denmark	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0
Germany	4	4	5	7	8	8	3	4	4
Netherlands	2	3	3	1	2	2	6	9	9
United Kingdom	10	15	15	8	11	11	15	23	23
	15	***22***	***23***	***17***	***23***	***23***	***27***	***41***	***41***

Table 4.2b variant 2

	Dec/Jan			Feb/Mar			Apr/May		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	2	3	3	1	2	2	1	1	1
Denmark	1	1	1	0	1	1	0	0	0
France	0	0	0	0	0	0	0	0	0
Germany	6	7	9	3	4	4	3	3	4
Netherlands	6	8	8	5	6	6	2	4	4
United Kingdom	12	19	19	3	6	6	7	11	11
	27	***39***	***40***	***12***	***18***	***18***	***12***	***19***	***20***
	Jun/Jul			**Aug/Sep**			**Oct/Nov**		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	0	0	0	1	2	2	2	3	3
Denmark	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0
Germany	3	4	4	5	6	6	3	3	4
Netherlands	1	2	2	1	2	2	5	8	8
United Kingdom	8	12	12	6	9	9	12	19	19
	12	***18***	***19***	***14***	***19***	***19***	***22***	***34***	***34***

Table 4.2c variant 3

	Dec/Jan			Feb/Mar			Apr/May		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	1	2	2	1	1	1	0	1	1
Denmark	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0
Germany	3	4	4	2	2	2	1	2	2
Netherlands	3	4	4	2	3	3	1	2	2
United Kingdom	6	9	9	1	3	3	3	5	5
	13	***19***	***19***	***6***	***9***	***9***	***6***	***9***	***9***
	Jun/Jul			**Aug/Sep**			**Oct/Nov**		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	0	0	0	1	1	1	1	1	1
Denmark	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0
Germany	2	2	2	3	3	3	1	2	2
Netherlands	1	1	1	1	1	1	2	4	4
United Kingdom	4	6	6	3	4	4	6	9	9
	6	***9***	***9***	***7***	***9***	***9***	***11***	***16***	***16***

Table 4.2d variant 4

	Dec/Jan			Feb/Mar			Apr/May		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	1	1	1	0	1	1	0	1	1
Denmark	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0
Germany	3	3	3	1	1	2	1	1	1
Netherlands	2	3	3	2	3	3	1	2	2
United Kingdom	5	8	8	1	2	2	3	4	4
	11	***16***	***16***	***5***	***7***	***7***	***5***	***8***	***8***
	Jun/Jul			**Aug/Sep**			**Oct/Nov**		
Country / scenario	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Belgium	0	0	0	1	1	1	1	1	1
Denmark	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0
Germany	1	1	2	2	2	3	1	1	1
Netherlands	1	1	1	0	1	1	2	3	3
United Kingdom	3	5	5	2	4	4	5	8	8
	5	***7***	***7***	***6***	***8***	***8***	***9***	***13***	***14***

4.2 Displacement numbers

4.2.1 Common guillemot

The largest cumulative number of displaced individuals of common guillemots in scenario 1 is calculated in the period August/September with 100,394 individuals per year (Table 4.3). In scenario 2, the largest cumulative number is found in December/January with 159,038 individuals, while most individuals in scenario 3 are displaced in June/July (222,326 individuals). The displaced numbers of common guillemot in the southern North Sea are generally lowest in April/May and October/November, and highest in the other four periods. In the periods June/July and August/September, the yearly number of displaced individuals tend to increase largely as a result of the addition of German wind farms in scenario 3. Therefore, German wind farms cause most displacement in terms of absolute numbers in these periods in the third scenario. In all other periods and scenarios, most guillemots are displaced by British wind farms.

The yearly number of displaced individuals of common guillemot per bimonthly period for each separate wind farm is presented in Appendix D.

*Table 4.3 The yearly number of displaced individuals of **common guillemot** per country and per scenario for each of the bimonthly periods in the ESAS/MWTL database. Note that the scenarios are cumulative, which means that they also include wind farms from the previous scenario(s). Also note that the total summed numbers below each column are calculated using the exact (unrounded) numbers, therefore these totals may slightly deviate from the sum of the presented (rounded) numbers in each column.*

	Dec/Jan			Feb/Mar		
Scenario	**1**	**2**	**3**	**1**	**2**	**3**
Country						
Belgium	3,113	7,199	7,199	1,965	5,514	5,514
Denmark	375	889	889	170	304	304
France	0	1,053	1,053	0	1,784	1,784
Germany	16,276	43,999	49,968	15,816	30,280	36,864
Netherlands	12,481	23,215	25,816	5,803	15,170	16,242
United Kingdom	63,254	82,684	82,684	29,015	79,185	79,185
	95,499	***159,038***	***167,608***	***52,770***	***132,237***	***139,894***
	Apr/May			**Jun/Jul**		
Scenario	**1**	**2**	**3**	**1**	**2**	**3**
Country						
Belgium	46	501	501	0	0	0
Denmark	66	111	111	944	1,776	1,776
France	0	4	4	0	0	0
Germany	1,833	5,478	6,647	21,051	42,772	121,841
Netherlands	1,905	7,541	9,125	3,991	9,995	12,157
United Kingdom	37,461	53,643	53,643	68,287	86,552	86,552
	41,311	***67,278***	***70,031***	***94,274***	***141,095***	***222,326***
	Aug/Sep			**Oct/Nov**		
Scenario	**1**	**2**	**3**	**1**	**2**	**3**
Country						
Belgium	13	46	46	1,861	2,638	2,638
Denmark	467	817	817	391	914	914
France	0	0	0	0	533	533
Germany	23,289	48,528	117,505	12,682	24,498	30,124
Netherlands	2,843	8,980	13,013	9,409	19,032	21,367
United Kingdom	73,783	90,841	90,841	9,089	38,183	38,183
	100,394	***149,211***	***222,221***	***33,431***	***85,800***	***93,761***

4.2.2 Red-throated diver

The displaced numbers of red-throated divers are lower than those of common guillemot. In all scenarios, the maximum number of individuals of red-throated divers are displaced in the period April/May, with respectively 12,473; 14,624 and 20,804 individuals per year in scenario 1, 2 and 3 (Table 4.4). During the breeding season in the periods June/July and August/September, hardly any red-throated divers are displaced in the southern North Sea, as they tend to breed further up north. In each period and each scenario, the largest displaced numbers of red-throated divers are calculated for German wind farms.

The yearly number of displaced individuals of red-throated divers per bimonthly period for each separate wind farm is presented in Appendix E.

*Table 4.4 The yearly number of displaced individuals of **red-throated diver** per country and per scenario for each of the bimonthly periods in the ESAS/MWTL database. Note that the scenarios are cumulative, which means that they also include wind farms from the previous scenario(s). Also note that the total summed numbers below each column are calculated using the exact (unrounded) numbers, therefore these totals may slightly deviate from the sum of the presented (rounded) numbers in each column.*

	Dec/Jan			Feb/Mar		
Scenario	**1**	**2**	**3**	**1**	**2**	**3**
Country						
Belgium	260	268	268	130	194	194
Denmark	440	622	622	184	310	310
France	0	153	153	0	684	684
Germany	9,244	9,377	9,377	6,951	9,185	11,071
Netherlands	182	206	208	353	386	468
United Kingdom	223	361	361	1,709	1,784	1,784
	10,350	***10,988***	***10,989***	***9,327***	***12,543***	***14,512***
	Apr/May			**Jun/Jul**		
Scenario	**1**	**2**	**3**	**1**	**2**	**3**
Country						
Belgium	0	249	249	0	0	0
Denmark	769	1,288	1,288	0	0	0
France	0	14	14	0	0	0
Germany	11,148	11,982	18,071	0	0	0
Netherlands	361	545	636	0	0	0
United Kingdom	195	546	546	2	2	2
	12,473	***14,624***	***20,804***	***2***	***2***	***2***
	Aug/Sep			**Oct/Nov**		
Scenario	**1**	**2**	**3**	**1**	**2**	**3**
Country						
Belgium	0	0	0	58	340	340
Denmark	0	0	0	72	115	115
France	0	0	0	0	24	24
Germany	2	2	2	1,734	1,981	1,984
Netherlands	0	0	0	59	73	84
United Kingdom	0	0	0	487	525	525
	2	***2***	***2***	***2,411***	***3,058***	***3,072***

5 Discussion and recommendations

The report at hand presents the cumulative number of casualties based on measured bird densities in operational or future offshore wind farms in the southern North Sea. The report considers collision victims of black-legged kittiwakes and lesser black-backed gulls calculated by the extended Band model (Band 2012), and displacement victims of red-throated divers and common guillemots based on basic assumptions on effect sizes and -distances. Empirical estimates on bird victims from offshore windfarms are almost absent (but see Skov *et al.* 2018), and hence the current common practice is to model these victim numbers. Although the first question could be whether or not models are at all suitable to be used in assessment studies, this dialogue is not part of the current study, as our report explicitly focuses on the evaluation and possible improvements of an existing model and how it can be used to determine population effects. Therefore, here we discuss how different methods or new insights into certain knowledge gaps could further improve the accuracy of the estimated mortality numbers in this report. Furthermore, within this chapter we provide recommendations on how these cumulative numbers (collision mortality and numbers of displaced birds, respectively) can be assessed in terms of impacts at the population level.

5.1 Bird distribution data

The distribution data used in the models originate from the ESAS and MWTL databases, the best available international seabird databases. Van Kooten *et al.* (2019) argue that it has proven difficult over the recent years to maintain the international ESAS database, and that not all survey data is currently incorporated in the database, as (1) not all data is being forwarded to ESAS and (2) new parties have emerged that collect survey data but have not all become partners of ESAS. Furthermore, most surveys tend to focus on national waters, while international surveys have become increasingly rare. For the models used in this study, distribution data from these databases are important input and therefore these models strongly rely on the accessibility and quality of these data. Compiling all existing data on seabirds into one publicly accessible platform is therefore essential and might also encourage currently reluctant parties to share all their available data. At this moment, a revitalization of ESAS in the near future would be the most reasonable, in order to feed international studies that focus on large-scale impact assessments (Van Kooten *et al.* 2019).

5.2 Band model

The current calculations for collision victims are based on the best currently available estimates of the model parameters. However, there is a margin of uncertainty in all input parameters and hence also in the results. Band (2012) stresses the importance of identifying uncertainties in the Band model, but acknowledges that uncertainties are currently largely based on expert judgment.

Recently, Marine Scotland published a Stochastic Collision Risk Model (sCRM, Marine Scotland 2018), in which variation in input parameters results in a range around the estimated number of victims. Thus, the sCRM provides insight into the uncertainty in the model outcomes and into which parameters mostly influence the model outcomes. For example, analyses with the sCRM for a selection of species (lesser black-backed gull, great black-backed gull, herring gull, kittiwake, great skua and gannet) showed that flight height distribution was one of the parameters most strongly affecting the estimated number of collision victims (Potiek *et al.* 2019). Hence, knowledge of flight height distributions is important to get a reliable estimate of the number of victims.

For either the Band model or the stochastic Collision Risk Model, the accuracy of the estimates of collision victims could be greatly improved by collecting additional empirical data. Especially for flight height, flight speed and avoidance, there is a strong need for more field observations. These data could for instance be collected by applying year-round GPS tags on individual seabirds, which preferably make use of areas in and around offshore wind farms. In that way, we can increase our understanding of behavioural responses of seabirds to wind farms and improve the accuracy of the collision risk model estimates.

5.3 Improving displacement level and mortality estimates

This study takes a precautionary approach by assuming a displacement level of 100% within the footprint area and a buffer zone of each wind farm, meaning that all birds inside this area are displaced. However, field observations in existing offshore wind farms suggest that not all guillemots and red-throated divers are displaced from offshore windfarms and some individuals of these species continue foraging within and around wind farms (Petersen *et al.* 2006; Welcker & Nehls 2016; Skov *et al.* 2017). These observations seem to indicate that displacement is time- and spatial dependent. Moreover, the effect of ship traffic accompanying the development of an offshore wind farm (i.e. daily movements of maintenance vessels), is currently entangled in the effect of wind farms themselves (Mendel *et al.* 2019). Therefore, more pre- and post-construction monitoring of seabirds inside and around wind farm perimeters can further improve our understanding of the driving factors of displacement. It is desirable that such efforts extend to longer periods after the construction of a wind farm or the observations are repeated after many years the wind farm became operational, in order to investigate the possibility that birds habituate to the presence of wind turbines. This is especially important in countries where fishing is restricted within offshore wind farms, which can theoretically create enhanced foraging possibilities for piscivorous sea birds inside offshore wind farms.

In accordance with the method of Bradbury *et al.* (2014), previous calculations as part of the KEC studies (Rijkswaterstaat 2015, 2019) made the assumption that 10% of the birds displaced by wind farms would suffer from displacement mortality. This arbitrary assumption was made due to the lack of more realistic data. Therefore, the impact of displacement in our current study was expressed as the number of displaced individuals, without making an assumption on the mortality rate of these displaced individuals. However, assessments of effects of wind farms in Environmental Impact Assessments (EIA) and Appropriate Assessments (AA) often require mortality estimates as an input. Thus, merely presenting the number of displaced individuals may not suffice for such purposes. Therefore, one of the most urgent knowledge gaps in the effects of offshore windfarms on birds is a better understanding of the impact of displacement on an individual. This could potentially be filled by long-term tagging of birds in the vicinity of offshore wind farms in development and analyse their spatial distribution, energy expenditure in terms of flight behaviour, coupled with investigating the dietary behaviour and reproductive output of the same individuals. Using such empirical data in more detailed population level models could provide more realistic estimates of mortality levels as a consequence of displacement at the population level (van Kooten *et al.* 2019).

5.4 Cumulative (mortality) numbers

The study at hand presents the cumulative effects of collisions on lesser black-backed gulls and black-legged kittiwakes, and of displacement on common guillemots and red-throated divers. These species were selected as they are identified as of international concern in the countries around the North Sea and are expected to be mostly affected by either collision or displacement. However, it needs to be stressed that these four species may not exclusively be affected by either collisions or displacement. For example, it is possible that not only the guillemots and divers will be displaced by offshore wind farms but also some lesser black-backed gulls and black-legged kittiwakes. Therefore, the actual cumulative number of birds that are affected by offshore wind farms in the southern North Sea may be higher than the numbers presented in this report.

The collision and displacement calculations of this study are carried out based on bimonthly bird densities recorded in the ESAS and MWTL database, in accordance with the KEC studies (Rijkswaterstaat 2015, 2019). In contrast to these studies, however, here we present the collision mortality and displacement numbers separately for these bimonthly periods, rather than presenting annual mortality numbers based on the sums of the victims in the bimonthly periods. As no bird can die twice, summing victim numbers assumes that different individuals are counted during the monitoring and subsequently suffered mortality in the different bimonthly periods. In reality, this approach leads to an overestimation of the cumulative mortality numbers because birds may be present in a given area for more than one or two months. However, it is currently not well-known how long individuals of a certain species stay in the vicinity of a certain wind farm, and hence the magnitude of this overestimation cannot precisely be determined. Therefore, the decision was made to merely present bimonthly (mortality) numbers in this study.

Ideally, knowledge on residence times of birds in certain areas should be gained per species and per region, and for example fed into individual-based models (see §5.5). Collecting reliable estimates on such spatial- and species-specific residence times requires large-scale tagging studies in all regions of the southern North Sea. Until such information becomes available, the best way forward is to address this problem by using monthly or bimonthly mortality numbers in population models relative to population sizes in the same period, which approach is discussed in §5.6.

5.5 Individual-based models

An alternative approach to model the effects of collision and displacement on seabirds is to develop individual-based models (IBM's; Eichhorn *et al.* 2012, Grünkorn *et al.* 2016). IBM's are models that simulate individuals in a population as discrete and autonomous entities (Huston *et al.* 1988; DeAngelis & Grimm 2014). These models can take into account different individual behaviours of birds and behavioural changes over time and distinguish between effects on birds of different age classes in different seasons. Furthermore, they can deal with the typical energetics of individuals of a certain species and the additional energetic costs resulting from the presence of wind farms (Searle *et al.* 2019; Van Kooten *et al.* 2019). With IBM's, mortality rates can be compared between a baseline scenario with no wind farms and scenarios with offshore wind farm development, and subsequently be fed into population models (see §5.6). Therefore, IBM's are generally likely to provide more accurate predictions on the effects of collision and displacement.

A disadvantage of IBM's is that they require a lot more specific data on the behaviour of individuals from bird species than is currently available. Also, they demand a lot of time and resources to be developed. Hence so far, IBM's have only been applied to predict the effects on specific species or in specific geographical areas (Eichhorn *et al.* 2012, Grünkorn *et al.* 2016) and even less so to offshore wind farm developments (Searle *et al.* 2019; Van Kooten *et al.* 2019). The application of IBM's in the assessment of cumulative effects of offshore wind farm developments might therefore best be implemented in a gradual manner, incorporating newly gained information step-by-step. This new information can for example be gained from comprehensive tracking studies, but possibly also from re-analysing and evaluating existing data and their use in the models. In the long-term, these models should ideally take into account factors such as (changes in) prey availability and prey distribution and effects of climate change. Also, IBM's could integrate collision risk and displacement effects into one model, but also probably deal with habituation to offshore wind farms and adaptive behaviour to rotating turbines. In that way, IBM's can be regarded as a valuable step forward in the assessment of cumulative effects of offshore wind farm developments on birds.

5.6 Impact on population level

In Environmental Impact Assessments (EIA) and Appropriate Assessments (AA) for future offshore wind farms, the effects of wind farm initiatives on bird species are often evaluated by criteria and thresholds like the ORNIS 1% criterion and the Potential Biological Removal (PBR) (Wade 1998; Dillingham & Fletcher 2008), which are straightforward and easy to apply. Therefore, these methodologies were adopted earlier in the first KEC study (Rijkswaterstaat 2015) and also in the actualised KEC 3.0 version, based on new data on turbine types, development plans, bird behaviour and bird densities (Rijkswaterstaat 2019).

However, these methods come with several limitations and may even result in false conclusions (O'Brien *et al.* 2017; Potiek *et al.* 2019). For example, the PBR approach provides a fixed and very static figure that does not take any environmental variability into account. Moreover, it implicitly assumes a fixed level of undemonstrated density dependence in population development (O'Brien *et al.* 2017). More detailed modelling is therefore needed to obtain a better and more profound understanding of the (cumulative) effects of the increasing number of offshore wind farms in the southern North Sea. Furthermore, an essential first step in any evaluation of effects at the population level is defining the population itself. For seabird species this can be reasonably difficult as many species have a large distribution and different populations may overlap.

One method that allows more detailed modelling of the cumulative impact of wind farms on a population level is to make use of matrix population models. Population models can predict population dynamics of species, based on the most up-to-date, scientific species-specific knowledge, and are likely to give better estimates of bird mortality associated with wind farms (Potiek *et al.* 2019). In population modelling, the population dynamics of a species without any wind farm development (null model) is compared to the population dynamics including the additional mortality caused by wind farms. The outcome of population models can be translated into probability distributions of a certain decline in a bird population as a result of wind farm development, and thus these models could provide a reliable metric to assess the cumulative effects of collision and displacement mortality at a population level. Furthermore, the summing of victims per year, which may lead to an overestimation of the number of victims (see §5.4), may also be avoided in population models by using mortality rates, instead of absolute numbers.

Recently, such population models have been developed for several seabird species to assess the cumulative impact of the wind farms of the KEC 3.0 study (Potiek *et al.* 2019; Van Kooten *et al.* 2019). These models could be applied to the different SEANSE scenarios, in order to assess the impact of the presented absolute mortality numbers on the populations of black-legged kittiwake, lesser black-backed gull, red-throated diver and common guillemot. As the ultimate aim of impact assessments is to understand the effect of offshore windfarms at the population level, the development of such population models is inevitable. Still, a very important decision policy-makers and scientists have to make is whether any population decrease is acceptable, or the use of a certain level of mortality (threshold) is acceptable, and if so what that is, without reaching a crucial tipping point, beyond which populations may collapse.

6 Literature

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Appendix A – Offshore wind farms per scenario

wind farm	country[1]	(expected) start of construction	total capacity (MW)	turbine capacity (MW)[2]	scale factor
Scenario 1					
Belwind	BE	2013	171	3	1
Mermaid	BE	2019	246	8	1
Norther	BE	2019	370	8	1
Northwester	BE	2019	219	9.5	1
Northwind	BE	2014	216	3	1
Rentel	BE	2018	309	7	1
Seastar	BE	2019	246	8	1
Thorton Bank	BE	2013	324	6	1
Horns Rev 3	DK	2018	400	8	0.46
Vesterhavet Nord/Syd	DK	2019	344	8	0.53
N-0.1	DE	2012-13	108	3.6	1
N-0.2	DE	2016	111	6	1
N-2.1	DE	2009	60	5	1
N-2.2	DE	2013-14	200	5	1
N-2.3	DE	2018-19	200	6.3	1
N-2.4	DE	2014	312	4	1
N-2.5	DE	2018-19	448	8	1
N-2.6	DE	2017-18	396	6	1
N-3.1	DE	2015-16	330	6	1
N-3.2	DE	2015-16	252	6	1
N-3.3	DE	2016-17	332	6	1
N-3.4	DE	2022-23	110	10	1.58
N-3.7	DE	2022-23	132	10	1.10
N-4.1	DE	2013-14	288	3.6	1
N-4.2	DE	2012-14	295	6	1
N-4.3	DE	2014-15	288	3.6	1
N-4.4	DE	2021-22	325	10	3.10
N-5.1	DE	2013-14	288	3.6	1
N-5.2	DE	2014	288	3.6	1
N-5.3	DE	2015-16	288	4	1
N-6.1	DE	2010-13	400	5	1
N-6.2	DE	2016-17	402	6	1
N-6.3	DE	2018-19	260	8.4	1
N-6.3-P	DE	2019	17	8.4	0.13
N-8.1	DE	2012-14	400	5	1
N-8.2	DE	2018-19	497	7	1
N-8.3	DE	2018-19	112	7	0.48

Borssele I & II	NL	2020	752	8	1.11
Borssele III & IV	NL	2020	752	9.5	1.03
Gemini	NL	2016	600	4	1
Hollandse Kust (Noord)	NL	2023	760	8	0.47
Hollandse Kust (Zuid) I & II	NL	2021	752	8	1.20
Hollandse Kust (Zuid) III & IV	NL	2021	752	8	1.15
Luchterduinen	NL	2015	129	3	1
OWEZ, Offshore Windpark Egmond aan Zee	NL	2015	108	3	1
Prinses Amaliawindpark	NL	2015	120	2	1
Beatrice BOWL	UK	2017	588	7	1
Dudgeon	UK	2016	402	6	1
East Anglia 1	UK	2018	714	7	0.58
Galloper	UK	2010	353	6	1
Greater Gabbard	UK	2008	504	4	1
Hornsea Project One	UK	2018	1,218	7	0.50
Hornsea Project Two	UK	2022	1,386	8	0.50
Hywind Scotland Pilot Park	UK	2017	30	6	0.09
Inch Cape	UK	2020	700	10	0.78
Inner Dowsing	UK	2008	97	3.6	1
Kincardine	UK	2020	50	9.5	0.08
Lincs	UK	2012	270	3.6	1
London Array	UK	2010	630	4	1
MORAY West	UK	2023	850	10	0.63
MORL – Stevenson, Telford, Macoll (Moray)	UK	2019	1,116	9.5	0.63
Neart na Gaoithe	UK	2020	450	7	0.71
Racebank	UK	2017	573	6	1
Repsol – Inchcape	UK	2023	784	10	0.87
Seagreen – Alpha en Bravo	UK	2020	1,050	7	0.45
Sheringham Shoal	UK	2012	317	3.6	1
Thanet	UK	2017	300	3	1
Thanet extension	UK	2023	340	10	0.78
Triton Knoll	UK	2010	860	6	1
Scenario 2					
Fairy Bank 1	BE	2025	700	10	1.25
Fairy Bank 2	BE	2027	700	12	1.37
Fairy Bank 3, N2000	BE	2030	700	15	2.59
Tender 2019	DK	2025	800	10	0.04
Dunkerque	FR	2025	750	12	1.02
N-1.1	DE	2024	240	10	2.80
N-1.2	DE	2024	240	10	2.48
N-1.3	DE	2024	420	10	2.36
N-3.5	DE	2028	420	12	3.29
N-3.6	DE	2028	480	12	1.70
N-3.7 (except Gode Wind 04)	DE	2026	225	12	1.28

N-3.8	DE	2026	375	12	2.44
N-6.6	DE	2029	630	12	2.52
N-6.7	DE	2029	270	12	1.98
N-7.1	DE	2024-25	900	10	3.45
N-7.2	DE	2026-27	900	12	2.87
N-9.1 TF1	DE	2030	600	15	1.95
Hollandse Kust (West) I	NL	2024	760	10	0.82
Hollandse Kust (West) II	NL	2025	760	10	0.71
Ijmuiden Ver I	NL	2027	1,000	10	1.34
Ijmuiden Ver II	NL	2028	1,000	10	1.61
Ijmuiden Ver III	NL	2029	1,450	10	1.73
Ijmuiden Ver IV	NL	2030	1,450	10	1.96
North of Waddeneilanden	NL	2026	760	10	1.37
Dogger Bank - Teesside A	UK	2030	1,200	10	0.36
Dogger Bank Creyke Beck A	UK	2030	1,200	15	0.39
Dogger Bank Creyke Beck B	UK	2030	1,200	15	0.33
Dogger Bank Sofia	UK	2030	1,200	15	0.34
East Anglia 1 North	UK	2025	800	10	0.64
East Anglia 2	UK	2024	800	10	0.52
East Anglia 3	UK	2030	1,200	8	0.66
Hornsea Project Three	UK	2030	2,400	8	0.57
Norfolk Boreas	UK	2030	1,800	10	0.41
Norfolk Vanguard	UK	2030	1,800	10	0.51
Scenario 3					
N-10	DE	2033	1,700	15*	1.75
N-11	DE	2034-36	3,550	15*	1.71
N-12	DE	2036-38	2,000	15*	1.41
N-13	DE	2038-40	2,000	15*	1.46
N-8.4	DE	2031	300	15*	1.78
N-9.1 TF2	DE	2031	400	15*	1.95
N-9.2	DE	2032	1,000	15*	1.78
North East Ijmuiden	NL	2032	2,000	15*	0.46
North North Wadden	NL	2033	2,000	15*	0.53

[1] BE = Belgium, DK = Denmark, FR = France, DE = Germany, NL = Netherlands, UK = United Kingdom.

[2] Turbine capacity corresponds with the turbine parameters given in Table 2.3.

Appendix B – Collision mortality of lesser black-backed gull per wind farm

B.1 - variant 1

wind farm	country	dec-jan	feb-mar	apr-may	jun-jul	aug-sep	oct-nov
Scenario 1							
Belwind	BE	1	2	3	2	2	5
Mermaid	BE	0	1	1	1	1	1
Norther	BE	1	1	5	5	3	1
Northwester	BE	0	1	1	1	1	0
Northwind	BE	2	2	5	3	3	9
Rentel	BE	1	1	4	3	2	3
Seastar	BE	1	1	2	2	1	4
Thorton Bank	BE	1	1	9	6	2	2
Horns Rev 3	DK	0	2	1	2	1	0
Vesterhavet Nord/Syd	DK	0	0	1	16	1	0
N-0.1	DE	0	1	3	1	1	1
N-0.2	DE	0	0	0	1	1	0
N-2.1	DE	0	0	0	0	1	0
N-2.2	DE	0	0	1	1	3	0
N-2.3	DE	0	0	1	1	3	0
N-2.4	DE	0	1	1	2	4	1
N-2.5	DE	0	1	1	1	3	1
N-2.6	DE	0	1	1	2	5	1
N-3.1	DE	0	1	3	2	2	1
N-3.2	DE	0	1	2	2	1	0
N-3.3	DE	0	1	3	1	2	1
N-3.4	DE	0	0	1	1	0	0
N-3.7	DE	0	0	1	1	0	0
N-4.1	DE	1	1	2	1	3	1
N-4.2	DE	1	1	1	1	2	1
N-4.3	DE	1	2	2	1	1	1
N-4.4	DE	0	0	1	1	1	1
N-5.1	DE	0	1	1	1	8	0
N-5.2	DE	0	4	2	1	2	1
N-5.3	DE	0	1	1	1	1	0
N-6.1	DE	0	1	1	3	2	0
N-6.2	DE	0	0	1	4	1	0
N-6.3	DE	0	0	1	2	1	0
N-6.3-P	DE	0	0	0	0	0	0
N-8.1	DE	0	1	1	1	1	0

N-8.2	DE	0	1	1	2	2	0
N-8.3	DE	0	0	0	0	0	0
Borssele I & II	NL	0	4	5	6	2	3
Borssele III & IV	NL	1	2	4	5	3	3
Gemini	NL	0	1	4	8	7	0
Hollandse Kust (Noord)	NL	0	5	8	7	8	2
Hollandse Kust (Zuid) I & II	NL	1	3	7	13	4	2
Hollandse Kust (Zuid) III & IV	NL	1	2	8	12	6	2
Luchterduinen	NL	0	1	3	4	2	0
OWEZ, Offshore Windpark Egmond aan Zee	NL	0	1	2	3	2	1
Prinses Amaliawindpark	NL	0	3	5	4	5	1
Beatrice BOWL	UK	0	3	2	0	0	0
Dudgeon	UK	0	0	0	0	0	0
East Anglia 1	UK	1	1	5	6	4	2
Galloper	UK	0	1	2	4	2	0
Greater Gabbard	UK	0	2	8	9	4	1
Hornsea Project One	UK	0	1	1	0	4	0
Hornsea Project Two	UK	0	1	2	0	4	0
Hywind Scotland Pilot Park	UK	0	0	0	0	0	0
Inch Cape	UK	0	0	0	0	1	0
Inner D, Racebank, Lincs, S. Shoal	UK	0	0	4	0	2	0
Kincardine	UK	0	0	0	0	0	0
London Array	UK	0	2	4	5	5	6
MORAY West	UK	0	10	1	0	0	0
MORL – Stevenson, Telford, Macoll (Moray)	UK	0	11	1	0	0	0
Neart na Gaoithe	UK	0	0	0	1	0	1
Repsol – Inchcape	UK	0	0	0	0	1	0
Seagreen – Alpha en Bravo	UK	0	0	0	1	0	0
Thanet	UK	0	1	2	2	1	4
Thanet extension	UK	0	0	1	1	1	1
Triton Knoll	UK	0	0	1	0	1	1
Scenario 2							
Fairy Bank 1	BE	1	1	3	3	3	4
Fairy Bank 2	BE	1	1	2	2	2	15
Fairy Bank 3, N2000	BE	1	1	2	3	2	21
Tender 2019	DK	0	2	3	4	1	0
Dunkerque	FR	1	1	3	5	3	3
N-1.1	DE	0	0	1	1	1	0
N-1.2	DE	0	0	1	1	1	0
N-1.3	DE	0	0	1	2	2	0
N-3.5	DE	0	0	2	1	1	0
N-3.6	DE	0	1	2	1	2	0
N-3.7 (except Gode Wind 04)	DE	0	0	1	1	0	0
N-3.8	DE	0	0	1	1	1	0

N-6.6	DE	0	0	1	2	2	0
N-6.7	DE	0	0	0	1	0	0
N-7.1	DE	0	1	2	2	2	0
N-7.2	DE	0	1	2	1	3	1
N-9.1 TF1	DE	0	0	0	1	1	0
Hollandse Kust (West) I	NL	0	3	4	3	2	2
Hollandse Kust (West) II	NL	0	2	3	2	2	2
Ijmuiden Ver I	NL	0	2	7	8	1	3
Ijmuiden Ver II	NL	0	1	8	8	4	3
Ijmuiden Ver III	NL	0	2	8	9	2	4
Ijmuiden Ver IV	NL	0	2	11	7	4	3
North of Waddeneilanden	NL	0	1	2	6	1	0
Dogger Bank - Teesside A	UK	0	0	1	1	2	0
Dogger Bank Creyke Beck A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck B	UK	0	0	0	0	0	0
Dogger Bank Sofia	UK	0	0	2	0	0	0
East Anglia 1 North	UK	1	0	4	5	3	2
East Anglia 2	UK	0	0	3	2	4	0
East Anglia 3	UK	1	7	8	4	4	6
Hornsea Project Three	UK	0	0	8	6	8	0
Norfolk Boreas	UK	0	2	7	11	5	1
Norfolk Vanguard	UK	0	4	8	7	3	0
Scenario 3							
N-10	DE	0	1	1	1	1	0
N-11	DE	0	1	2	3	2	0
N-12	DE	0	1	1	2	1	0
N-13	DE	0	1	1	3	1	0
N-8.4	DE	0	0	0	0	0	0
N-9.1 TF2	DE	0	0	0	1	0	0
N-9.2	DE	0	0	1	1	1	0
North East Ijmuiden	NL	0	5	6	5	3	1
North North Wadden	NL	0	0	2	5	2	0

B.2 - variant 2

wind farm	country	dec-jan	feb-mar	apr-may	jun-jul	aug-sep	oct-nov
Scenario 1							
Belwind	BE	1	1	3	2	2	5
Mermaid	BE	0	1	1	1	1	1
Norther	BE	1	1	4	5	2	1
Northwester	BE	0	1	1	1	1	0
Northwind	BE	2	2	4	3	3	8
Rentel	BE	1	1	4	3	2	3
Seastar	BE	1	1	2	1	1	4
Thorton Bank	BE	1	1	8	6	2	2
Horns Rev 3	DK	0	2	1	2	1	0
Vesterhavet Nord/Syd	DK	0	0	1	15	1	0
N-0.1	DE	0	1	3	1	0	1
N-0.2	DE	0	0	0	1	1	0
N-2.1	DE	0	0	0	0	1	0
N-2.2	DE	0	0	1	1	3	0
N-2.3	DE	0	0	1	1	2	0
N-2.4	DE	0	1	1	1	4	1
N-2.5	DE	0	1	1	1	3	1
N-2.6	DE	0	1	1	1	5	1
N-3.1	DE	0	1	2	2	1	1
N-3.2	DE	0	1	2	2	1	0
N-3.3	DE	0	1	2	1	2	1
N-3.4	DE	0	0	0	1	0	0
N-3.7	DE	0	0	1	1	0	0
N-4.1	DE	1	1	2	1	3	1
N-4.2	DE	1	0	1	1	2	1
N-4.3	DE	1	2	1	1	1	1
N-4.4	DE	0	0	1	0	1	1
N-5.1	DE	0	1	1	1	7	0
N-5.2	DE	0	4	2	1	2	1
N-5.3	DE	0	1	1	1	1	0
N-6.1	DE	0	0	1	3	2	0
N-6.2	DE	0	0	1	4	1	0
N-6.3	DE	0	0	1	2	1	0
N-6.3-P	DE	0	0	0	0	0	0
N-8.1	DE	0	1	1	1	1	0
N-8.2	DE	0	1	1	1	2	0
N-8.3	DE	0	0	0	0	0	0
Borssele I & II	NL	0	4	5	5	2	2
Borssele III & IV	NL	1	2	4	4	3	3

Gemini	NL	0	1	4	8	6	0
Hollandse Kust (Noord)	NL	0	4	8	7	7	2
Hollandse Kust (Zuid) I & II	NL	1	2	7	12	4	1
Hollandse Kust (Zuid) III & IV	NL	1	2	7	12	6	1
Luchterduinen	NL	0	1	3	3	1	0
OWEZ, Offshore Windpark Egmond aan Zee	NL	0	1	2	2	2	1
Prinses Amaliawindpark	NL	0	2	5	4	4	1
Beatrice BOWL	UK	0	3	1	0	0	0
Dudgeon	UK	0	0	0	0	0	0
East Anglia 1	UK	1	1	4	5	4	1
Galloper	UK	0	1	2	4	2	0
Greater Gabbard	UK	0	2	7	8	4	1
Hornsea Project One	UK	0	1	1	0	4	0
Hornsea Project Two	UK	0	1	2	0	4	0
Hywind Scotland Pilot Park	UK	0	0	0	0	0	0
Inch Cape	UK	0	0	0	0	1	0
Inner D, Racebank, Lincs, S. Shoal	UK	0	0	3	0	2	0
Kincardine	UK	0	0	0	0	0	0
London Array	UK	0	2	4	5	5	6
MORAY West	UK	0	9	1	0	0	0
MORL – Stevenson, Telford, Macoll (Moray)	UK	0	10	1	0	0	0
Neart na Gaoithe	UK	0	0	0	1	0	1
Repsol – Inchcape	UK	0	0	0	0	1	0
Seagreen – Alpha en Bravo	UK	0	0	0	1	0	0
Thanet	UK	0	1	2	2	1	4
Thanet extension	UK	0	0	1	1	0	1
Triton Knoll	UK	0	0	1	0	1	1
Scenario 2							
Fairy Bank 1	BE	1	1	3	3	3	4
Fairy Bank 2	BE	1	1	2	2	2	14
Fairy Bank 3, N2000	BE	1	1	2	3	2	19
Tender 2019	DK	0	2	3	3	1	0
Dunkerque	FR	1	1	3	4	2	2
N-1.1	DE	0	0	1	1	1	0
N-1.2	DE	0	0	1	1	1	0
N-1.3	DE	0	0	1	2	2	0
N-3.5	DE	0	0	2	1	1	0
N-3.6	DE	0	0	2	1	2	0
N-3.7 (except Gode Wind 04)	DE	0	0	1	1	0	0
N-3.8	DE	0	0	1	1	1	0
N-6.6	DE	0	0	1	2	2	0
N-6.7	DE	0	0	0	1	0	0
N-7.1	DE	0	1	2	2	2	0
N-7.2	DE	0	1	2	1	3	1

N-9.1 TF1	DE	0	0	0	1	1	0
Hollandse Kust (West) I	NL	0	2	4	2	1	2
Hollandse Kust (West) II	NL	0	2	3	2	2	2
Ijmuiden Ver I	NL	0	2	7	7	1	3
Ijmuiden Ver II	NL	0	1	8	8	4	3
Ijmuiden Ver III	NL	0	2	7	9	2	4
Ijmuiden Ver IV	NL	0	1	10	7	3	3
North of Waddeneilanden	NL	0	1	2	5	1	0
Dogger Bank - Teesside A	UK	0	0	1	1	1	0
Dogger Bank Creyke Beck A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck B	UK	0	0	0	0	0	0
Dogger Bank Sofia	UK	0	0	2	0	0	0
East Anglia 1 North	UK	1	0	3	5	3	2
East Anglia 2	UK	0	0	3	2	4	0
East Anglia 3	UK	1	7	8	4	3	5
Hornsea Project Three	UK	0	0	8	6	8	0
Norfolk Boreas	UK	0	2	7	10	5	1
Norfolk Vanguard	UK	0	4	8	7	3	0
Scenario 3							
N-10	DE	0	1	1	1	1	0
N-11	DE	0	1	2	3	2	0
N-12	DE	0	1	1	2	1	0
N-13	DE	0	1	1	2	1	0
N-8.4	DE	0	0	0	0	0	0
N-9.1 TF2	DE	0	0	0	0	0	0
N-9.2	DE	0	0	1	1	1	0
North East Ijmuiden	NL	0	4	6	4	3	1
North North Wadden	NL	0	0	2	4	2	0

B.3 - variant 3

wind farm	country	dec-jan	feb-mar	apr-may	jun-jul	aug-sep	oct-nov
Scenario 1							
Belwind	BE	0	1	1	1	1	2
Mermaid	BE	0	0	1	0	0	0
Norther	BE	0	1	2	2	1	1
Northwester	BE	0	0	0	0	0	0
Northwind	BE	1	1	2	1	1	4
Rentel	BE	0	0	2	1	1	1
Seastar	BE	0	0	1	1	1	2
Thorton Bank	BE	0	0	4	2	1	1
Horns Rev 3	DK	0	1	0	1	0	0
Vesterhavet Nord/Syd	DK	0	0	0	6	0	0
N-0.1	DE	0	0	1	1	0	0
N-0.2	DE	0	0	0	0	0	0
N-2.1	DE	0	0	0	0	0	0
N-2.2	DE	0	0	0	0	1	0
N-2.3	DE	0	0	0	0	1	0
N-2.4	DE	0	0	1	1	2	0
N-2.5	DE	0	0	0	1	1	0
N-2.6	DE	0	0	1	1	2	0
N-3.1	DE	0	0	1	1	1	0
N-3.2	DE	0	0	1	1	0	0
N-3.3	DE	0	0	1	0	1	0
N-3.4	DE	0	0	0	0	0	0
N-3.7	DE	0	0	0	0	0	0
N-4.1	DE	0	0	1	1	1	0
N-4.2	DE	0	0	0	0	1	0
N-4.3	DE	0	1	1	0	0	1
N-4.4	DE	0	0	0	0	0	0
N-5.1	DE	0	0	0	0	3	0
N-5.2	DE	0	2	1	1	1	0
N-5.3	DE	0	0	0	0	1	0
N-6.1	DE	0	0	1	1	1	0
N-6.2	DE	0	0	0	2	1	0
N-6.3	DE	0	0	0	1	0	0
N-6.3-P	DE	0	0	0	0	0	0
N-8.1	DE	0	0	1	1	1	0
N-8.2	DE	0	0	1	1	1	0
N-8.3	DE	0	0	0	0	0	0
Borssele I & II	NL	0	2	2	2	1	1
Borssele III & IV	NL	0	1	2	2	1	1

Gemini	NL	0	0	2	3	3	0
Hollandse Kust (Noord)	NL	0	2	3	3	3	1
Hollandse Kust (Zuid) I & II	NL	0	1	3	5	2	1
Hollandse Kust (Zuid) III & IV	NL	0	1	3	5	2	1
Luchterduinen	NL	0	1	1	1	1	0
OWEZ, Offshore Windpark Egmond aan Zee	NL	0	1	1	1	1	0
Prinses Amaliawindpark	NL	0	1	2	2	2	0
Beatrice BOWL	UK	0	1	1	0	0	0
Dudgeon	UK	0	0	0	0	0	0
East Anglia 1	UK	0	0	2	2	1	1
Galloper	UK	0	0	1	2	1	0
Greater Gabbard	UK	0	1	3	3	2	0
Hornsea Project One	UK	0	0	0	0	2	0
Hornsea Project Two	UK	0	0	1	0	2	0
Hywind Scotland Pilot Park	UK	0	0	0	0	0	0
Inch Cape	UK	0	0	0	0	0	0
Inner D, Racebank, Lincs, S. Shoal	UK	0	0	1	0	1	0
Kincardine	UK	0	0	0	0	0	0
London Array	UK	0	1	2	2	2	2
MORAY West	UK	0	4	0	0	0	0
MORL – Stevenson, Telford, Macoll (Moray)	UK	0	4	0	0	0	0
Neart na Gaoithe	UK	0	0	0	0	0	0
Repsol – Inchcape	UK	0	0	0	0	0	0
Seagreen – Alpha en Bravo	UK	0	0	0	0	0	0
Thanet	UK	0	0	1	1	1	2
Thanet extension	UK	0	0	0	0	0	1
Triton Knoll	UK	0	0	0	0	1	0
Scenario 2							
Fairy Bank 1	BE	0	0	1	1	1	2
Fairy Bank 2	BE	0	0	1	1	1	6
Fairy Bank 3, N2000	BE	1	0	1	1	1	8
Tender 2019	DK	0	1	1	1	0	0
Dunkerque	FR	0	0	1	2	1	1
N-1.1	DE	0	0	0	0	0	0
N-1.2	DE	0	0	0	0	0	0
N-1.3	DE	0	0	1	1	1	0
N-3.5	DE	0	0	1	0	0	0
N-3.6	DE	0	0	1	0	1	0
N-3.7 (except Gode Wind 04)	DE	0	0	0	0	0	0
N-3.8	DE	0	0	1	0	0	0
N-6.6	DE	0	0	0	1	1	0
N-6.7	DE	0	0	0	0	0	0
N-7.1	DE	0	0	1	1	1	0
N-7.2	DE	0	0	1	1	1	0

N-9.1 TF1	DE	0	0	0	0	0	0
Hollandse Kust (West) I	NL	0	1	2	1	1	1
Hollandse Kust (West) II	NL	0	1	1	1	1	1
Ijmuiden Ver I	NL	0	1	3	3	0	1
Ijmuiden Ver II	NL	0	0	3	3	1	1
Ijmuiden Ver III	NL	0	1	3	4	1	2
Ijmuiden Ver IV	NL	0	1	4	3	1	1
North of Waddeneilanden	NL	0	0	1	2	1	0
Dogger Bank - Teesside A	UK	0	0	0	0	1	0
Dogger Bank Creyke Beck A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck B	UK	0	0	0	0	0	0
Dogger Bank Sofia	UK	0	0	1	0	0	0
East Anglia 1 North	UK	0	0	1	2	1	1
East Anglia 2	UK	0	0	1	1	2	0
East Anglia 3	UK	0	3	3	1	1	2
Hornsea Project Three	UK	0	0	3	2	3	0
Norfolk Boreas	UK	0	1	3	4	2	0
Norfolk Vanguard	UK	0	2	3	3	1	0
Scenario 3							
N-10	DE	0	0	0	1	0	0
N-11	DE	0	1	1	1	1	0
N-12	DE	0	0	0	1	0	0
N-13	DE	0	0	0	1	0	0
N-8.4	DE	0	0	0	0	0	0
N-9.1 TF2	DE	0	0	0	0	0	0
N-9.2	DE	0	0	0	0	0	0
North East Ijmuiden	NL	0	2	2	2	1	0
North North Wadden	NL	0	0	1	2	1	0

B.4 - variant 4

wind farm	country	dec-jan	feb-mar	apr-may	jun-jul	aug-sep	oct-nov
Scenario 1							
Belwind	BE	0	1	1	1	1	2
Mermaid	BE	0	0	1	0	0	0
Norther	BE	0	0	2	2	1	1
Northwester	BE	0	0	0	0	0	0
Northwind	BE	1	1	2	1	1	3
Rentel	BE	0	0	2	1	1	1
Seastar	BE	0	0	1	1	1	2
Thorton Bank	BE	0	0	3	2	1	1
Horns Rev 3	DK	0	1	0	1	0	0
Vesterhavet Nord/Syd	DK	0	0	0	6	0	0
N-0.1	DE	0	0	1	1	0	0
N-0.2	DE	0	0	0	0	0	0
N-2.1	DE	0	0	0	0	0	0
N-2.2	DE	0	0	0	0	1	0
N-2.3	DE	0	0	0	0	1	0
N-2.4	DE	0	0	1	1	2	0
N-2.5	DE	0	0	0	0	1	0
N-2.6	DE	0	0	0	1	2	0
N-3.1	DE	0	0	1	1	1	0
N-3.2	DE	0	0	1	1	0	0
N-3.3	DE	0	0	1	0	1	0
N-3.4	DE	0	0	0	0	0	0
N-3.7	DE	0	0	0	0	0	0
N-4.1	DE	0	0	1	1	1	0
N-4.2	DE	0	0	0	0	1	0
N-4.3	DE	0	1	1	0	0	0
N-4.4	DE	0	0	0	0	0	0
N-5.1	DE	0	0	0	0	3	0
N-5.2	DE	0	2	1	1	1	0
N-5.3	DE	0	0	0	0	1	0
N-6.1	DE	0	0	1	1	1	0
N-6.2	DE	0	0	0	1	1	0
N-6.3	DE	0	0	0	1	0	0
N-6.3-P	DE	0	0	0	0	0	0
N-8.1	DE	0	0	0	1	0	0
N-8.2	DE	0	0	1	1	1	0
N-8.3	DE	0	0	0	0	0	0
Borssele I & II	NL	0	2	2	2	1	1
Borssele III & IV	NL	0	1	2	2	1	1

Gemini	NL	0	0	1	3	3	0
Hollandse Kust (Noord)	NL	0	2	3	3	3	1
Hollandse Kust (Zuid) I & II	NL	0	1	3	5	1	1
Hollandse Kust (Zuid) III & IV	NL	0	1	3	5	2	1
Luchterduinen	NL	0	1	1	1	1	0
OWEZ, Offshore Windpark Egmond aan Zee	NL	0	0	1	1	1	0
Prinses Amaliawindpark	NL	0	1	2	2	2	0
Beatrice BOWL	UK	0	1	1	0	0	0
Dudgeon	UK	0	0	0	0	0	0
East Anglia 1	UK	0	0	2	2	1	1
Galloper	UK	0	0	1	1	1	0
Greater Gabbard	UK	0	1	3	3	1	0
Hornsea Project One	UK	0	0	0	0	1	0
Hornsea Project Two	UK	0	0	1	0	1	0
Hywind Scotland Pilot Park	UK	0	0	0	0	0	0
Inch Cape	UK	0	0	0	0	0	0
Inner D, Racebank, Lincs, S. Shoal	UK	0	0	1	0	1	0
Kincardine	UK	0	0	0	0	0	0
London Array	UK	0	1	1	2	2	2
MORAY West	UK	0	4	0	0	0	0
MORL – Stevenson, Telford, Macoll (Moray)	UK	0	4	0	0	0	0
Neart na Gaoithe	UK	0	0	0	0	0	0
Repsol – Inchcape	UK	0	0	0	0	0	0
Seagreen – Alpha en Bravo	UK	0	0	0	0	0	0
Thanet	UK	0	0	1	1	1	1
Thanet extension	UK	0	0	0	0	0	1
Triton Knoll	UK	0	0	0	0	1	0
Scenario 2							
Fairy Bank 1	BE	0	0	1	1	1	2
Fairy Bank 2	BE	0	0	1	1	1	6
Fairy Bank 3, N2000	BE	0	0	1	1	1	8
Tender 2019	DK	0	1	1	1	0	0
Dunkerque	FR	0	0	1	2	1	1
N-1.1	DE	0	0	0	0	0	0
N-1.2	DE	0	0	0	0	0	0
N-1.3	DE	0	0	0	1	1	0
N-3.5	DE	0	0	1	0	0	0
N-3.6	DE	0	0	1	0	1	0
N-3.7 (except Gode Wind 04)	DE	0	0	0	0	0	0
N-3.8	DE	0	0	1	0	0	0
N-6.6	DE	0	0	0	1	1	0
N-6.7	DE	0	0	0	0	0	0
N-7.1	DE	0	0	1	1	1	0
N-7.2	DE	0	0	1	1	1	0

N-9.1 TF1	DE	0	0	0	0	0	0
Hollandse Kust (West) I	NL	0	1	2	1	1	1
Hollandse Kust (West) II	NL	0	1	1	1	1	1
Ijmuiden Ver I	NL	0	1	3	3	0	1
Ijmuiden Ver II	NL	0	0	3	3	1	1
Ijmuiden Ver III	NL	0	1	3	3	1	2
Ijmuiden Ver IV	NL	0	1	4	3	1	1
North of Waddeneilanden	NL	0	0	1	2	1	0
Dogger Bank - Teesside A	UK	0	0	0	0	1	0
Dogger Bank Creyke Beck A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck B	UK	0	0	0	0	0	0
Dogger Bank Sofia	UK	0	0	1	0	0	0
East Anglia 1 North	UK	0	0	1	2	1	1
East Anglia 2	UK	0	0	1	1	2	0
East Anglia 3	UK	0	3	3	1	1	2
Hornsea Project Three	UK	0	0	3	2	3	0
Norfolk Boreas	UK	0	1	3	4	2	0
Norfolk Vanguard	UK	0	2	3	3	1	0
Scenario 3							
N-10	DE	0	0	0	1	0	0
N-11	DE	0	0	1	1	1	0
N-12	DE	0	0	0	1	0	0
N-13	DE	0	0	0	1	0	0
N-8.4	DE	0	0	0	0	0	0
N-9.1 TF2	DE	0	0	0	0	0	0
N-9.2	DE	0	0	0	0	0	0
North East Ijmuiden	NL	0	2	2	2	1	0
North North Wadden	NL	0	0	1	2	1	0

Appendix C – Collision mortality of black-legged kittiwake per wind farm

C.1 - variant 1

wind farm	country	dec-jan	feb-mar	apr-may	jun-jul	aug-sep	oct-nov
Scenario 1							
Belwind	BE	1	0	0	0	0	0
Mermaid	BE	0	0	0	0	0	0
Norther	BE	0	0	0	0	0	0
Northwester	BE	0	0	0	0	0	0
Northwind	BE	1	0	0	0	0	0
Rentel	BE	0	0	0	0	0	0
Seastar	BE	0	0	0	0	0	0
Thorton Bank	BE	0	0	0	0	0	1
Horns Rev 3	DK	0	0	0	0	0	0
Vesterhavet Nord/Syd	DK	1	0	0	0	0	0
N-0.1	DE	0	0	0	0	0	0
N-0.2	DE	0	0	0	0	0	0
N-2.1	DE	0	0	0	0	0	0
N-2.2	DE	0	0	0	0	1	0
N-2.3	DE	0	0	0	0	1	0
N-2.4	DE	0	0	0	0	0	0
N-2.5	DE	0	0	0	0	0	0
N-2.6	DE	0	0	0	0	0	0
N-3.1	DE	0	0	0	0	0	0
N-3.2	DE	0	0	0	0	0	0
N-3.3	DE	0	0	0	0	0	0
N-3.4	DE	0	0	0	0	0	0
N-3.7	DE	0	0	0	0	0	0
N-4.1	DE	0	0	0	0	0	0
N-4.2	DE	0	0	0	0	0	0
N-4.3	DE	0	0	0	0	0	0
N-4.4	DE	0	0	0	0	0	0
N-5.1	DE	0	1	0	0	0	0
N-5.2	DE	1	1	0	0	0	0
N-5.3	DE	0	0	0	0	1	0
N-6.1	DE	2	0	0	0	0	0
N-6.2	DE	2	0	0	0	0	0
N-6.3	DE	0	0	0	0	0	0
N-6.3-P	DE	0	0	0	0	0	0
N-8.1	DE	1	0	0	0	0	0

N-8.2	DE	0	0	0	0	1	0
N-8.3	DE	0	0	0	0	0	0
Borssele I & II	NL	1	1	0	0	0	1
Borssele III & IV	NL	1	0	0	0	0	1
Gemini	NL	0	2	0	1	1	2
Hollandse Kust (Noord)	NL	1	1	0	0	0	0
Hollandse Kust (Zuid) I & II	NL	1	0	0	0	0	0
Hollandse Kust (Zuid) III & IV	NL	1	0	0	0	0	1
Luchterduinen	NL	0	0	0	0	0	0
OWEZ, Offshore Windpark Egmond aan Zee	NL	0	0	0	0	0	0
Prinses Amaliawindpark	NL	1	1	0	0	0	0
Beatrice BOWL	UK	1	0	0	1	0	0
Dudgeon	UK	0	0	0	0	0	1
East Anglia 1	UK	0	0	1	0	0	0
Galloper	UK	0	0	0	0	0	0
Greater Gabbard	UK	1	1	0	0	0	0
Hornsea Project One	UK	1	0	1	1	1	2
Hornsea Project Two	UK	1	0	0	1	1	2
Hywind Scotland Pilot Park	UK	0	0	0	0	0	0
Inch Cape	UK	0	0	0	0	0	0
Inner D, Racebank, Lincs, S. Shoal	UK	4	0	1	1	0	3
Kincardine	UK	0	0	0	0	0	0
London Array	UK	1	0	1	1	0	2
MORAY West	UK	0	0	0	0	0	0
MORL – Stevenson, Telford, Macoll (Moray)	UK	1	0	0	1	0	0
Neart na Gaoithe	UK	0	0	0	0	0	0
Repsol – Inchcape	UK	0	0	0	0	0	0
Seagreen – Alpha en Bravo	UK	0	0	0	1	1	1
Thanet	UK	0	0	0	1	0	1
Thanet extension	UK	0	0	0	0	0	0
Triton Knoll	UK	3	0	1	0	1	2
Scenario 2							
Fairy Bank 1	BE	0	0	0	0	0	0
Fairy Bank 2	BE	0	0	0	0	0	0
Fairy Bank 3, N2000	BE	0	0	0	0	0	0
Tender 2019	DK	0	1	0	0	0	0
Dunkerque	FR	0	0	0	0	0	0
N-1.1	DE	0	0	0	0	0	0
N-1.2	DE	0	0	0	0	0	0
N-1.3	DE	0	0	0	0	0	0
N-3.5	DE	0	0	0	0	0	0
N-3.6	DE	0	0	0	0	0	0
N-3.7 (except Gode Wind 04)	DE	0	0	0	0	0	0
N-3.8	DE	0	0	0	0	0	0

N-6.6	DE	0	0	0	0	0	0
N-6.7	DE	0	0	0	0	0	0
N-7.1	DE	0	0	0	0	0	0
N-7.2	DE	0	0	0	0	0	0
N-9.1 TF1	DE	0	0	0	0	0	0
Hollandse Kust (West) I	NL	0	0	0	0	0	0
Hollandse Kust (West) II	NL	0	0	0	0	0	0
Ijmuiden Ver I	NL	0	0	0	0	0	1
Ijmuiden Ver II	NL	0	0	0	0	0	1
Ijmuiden Ver III	NL	0	0	1	0	0	1
Ijmuiden Ver IV	NL	0	0	0	0	0	1
North of Waddeneilanden	NL	0	0	0	0	0	0
Dogger Bank - Teesside A	UK	0	0	0	0	0	1
Dogger Bank Creyke Beck A	UK	0	0	0	1	0	0
Dogger Bank Creyke Beck B	UK	0	0	0	1	0	0
Dogger Bank Sofia	UK	0	0	0	0	0	1
East Anglia 1 North	UK	0	0	1	0	0	0
East Anglia 2	UK	0	0	0	0	0	0
East Anglia 3	UK	1	0	0	0	0	2
Hornsea Project Three	UK	6	1	2	3	1	1
Norfolk Boreas	UK	0	0	0	0	0	1
Norfolk Vanguard	UK	0	1	0	0	0	2
Scenario 3							
N-10	DE	0	0	0	0	0	0
N-11	DE	0	0	0	0	0	0
N-12	DE	0	0	0	0	0	0
N-13	DE	0	0	0	0	0	0
N-8.4	DE	0	0	0	0	0	0
N-9.1 TF2	DE	0	0	0	0	0	0
N-9.2	DE	0	0	0	0	0	0
North East Ijmuiden	NL	0	0	0	0	0	0
North North Wadden	NL	0	0	0	0	0	0

C.2 - variant 2

wind farm	**country**	**dec-jan**	**feb-mar**	**apr-may**	**jun-jul**	**aug-sep**	**oct-nov**
Scenario 1							
Belwind	BE	0	0	0	0	0	0
Mermaid	BE	0	0	0	0	0	0
Norther	BE	0	0	0	0	0	0
Northwester	BE	0	0	0	0	0	0
Northwind	BE	1	0	0	0	0	0
Rentel	BE	0	0	0	0	0	0
Seastar	BE	0	0	0	0	0	0
Thorton Bank	BE	0	0	0	0	0	1
Horns Rev 3	DK	0	0	0	0	0	0
Vesterhavet Nord/Syd	DK	1	0	0	0	0	0
N-0.1	DE	0	0	0	0	0	0
N-0.2	DE	0	0	0	0	0	0
N-2.1	DE	0	0	0	0	0	0
N-2.2	DE	0	0	0	0	1	0
N-2.3	DE	0	0	0	0	1	0
N-2.4	DE	0	0	0	0	0	0
N-2.5	DE	0	0	0	0	0	0
N-2.6	DE	0	0	0	0	0	0
N-3.1	DE	0	0	0	0	0	0
N-3.2	DE	0	0	0	0	0	0
N-3.3	DE	0	0	0	0	0	0
N-3.4	DE	0	0	0	0	0	0
N-3.7	DE	0	0	0	0	0	0
N-4.1	DE	0	0	0	0	0	0
N-4.2	DE	0	0	0	0	0	0
N-4.3	DE	0	0	0	0	0	0
N-4.4	DE	0	0	0	0	0	0
N-5.1	DE	0	1	0	0	0	0
N-5.2	DE	1	1	0	0	0	0
N-5.3	DE	0	0	0	0	1	0
N-6.1	DE	2	0	0	0	0	0
N-6.2	DE	2	0	0	0	0	0
N-6.3	DE	0	0	0	0	0	0
N-6.3-P	DE	0	0	0	0	0	0
N-8.1	DE	0	0	0	0	0	0
N-8.2	DE	0	0	0	0	1	0
N-8.3	DE	0	0	0	0	0	0
Borssele I & II	NL	1	1	0	0	0	1
Borssele III & IV	NL	1	0	0	0	0	1

Gemini	NL	0	1	0	1	1	1
Hollandse Kust (Noord)	NL	1	1	0	0	0	0
Hollandse Kust (Zuid) I & II	NL	1	0	0	0	0	0
Hollandse Kust (Zuid) III & IV	NL	1	0	0	0	0	1
Luchterduinen	NL	0	0	0	0	0	0
OWEZ, Offshore Windpark Egmond aan Zee	NL	0	0	0	0	0	0
Prinses Amaliawindpark	NL	1	0	0	0	0	0
Beatrice BOWL	UK	1	0	0	0	0	0
Dudgeon	UK	0	0	0	0	0	1
East Anglia 1	UK	0	0	1	0	0	0
Galloper	UK	0	0	0	0	0	0
Greater Gabbard	UK	1	0	0	0	0	0
Hornsea Project One	UK	1	0	1	1	1	2
Hornsea Project Two	UK	1	0	0	0	1	2
Hywind Scotland Pilot Park	UK	0	0	0	0	0	0
Inch Cape	UK	0	0	0	0	0	0
Inner D, Racebank, Lincs, S. Shoal	UK	3	0	1	1	0	2
Kincardine	UK	0	0	0	0	0	0
London Array	UK	1	0	1	1	0	2
MORAY West	UK	0	0	0	0	0	0
MORL – Stevenson, Telford, Macoll (Moray)	UK	0	0	0	1	0	0
Neart na Gaoithe	UK	0	0	0	0	0	0
Repsol – Inchcape	UK	0	0	0	0	0	0
Seagreen – Alpha en Bravo	UK	0	0	0	1	0	1
Thanet	UK	0	0	0	1	0	1
Thanet extension	UK	0	0	0	0	0	0
Triton Knoll	UK	2	0	0	0	0	1
Scenario 2							
Fairy Bank 1	BE	0	0	0	0	0	0
Fairy Bank 2	BE	0	0	0	0	0	0
Fairy Bank 3, N2000	BE	0	0	0	0	0	0
Tender 2019	DK	0	0	0	0	0	0
Dunkerque	FR	0	0	0	0	0	0
N-1.1	DE	0	0	0	0	0	0
N-1.2	DE	0	0	0	0	0	0
N-1.3	DE	0	0	0	0	0	0
N-3.5	DE	0	0	0	0	0	0
N-3.6	DE	0	0	0	0	0	0
N-3.7 (except Gode Wind 04)	DE	0	0	0	0	0	0
N-3.8	DE	0	0	0	0	0	0
N-6.6	DE	0	0	0	0	0	0
N-6.7	DE	0	0	0	0	0	0
N-7.1	DE	0	0	0	0	0	0
N-7.2	DE	0	0	0	0	0	0

N-9.1 TF1	DE	0	0	0	0	0	0
Hollandse Kust (West) I	NL	0	0	0	0	0	0
Hollandse Kust (West) II	NL	0	0	0	0	0	0
Ijmuiden Ver I	NL	0	0	0	0	0	1
Ijmuiden Ver II	NL	0	0	0	0	0	0
Ijmuiden Ver III	NL	0	0	1	0	0	1
Ijmuiden Ver IV	NL	0	0	0	0	0	1
North of Waddeneilanden	NL	0	0	0	0	0	0
Dogger Bank - Teesside A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck B	UK	0	0	0	1	0	0
Dogger Bank Sofia	UK	0	0	0	0	0	0
East Anglia 1 North	UK	0	0	1	0	0	0
East Anglia 2	UK	0	0	0	0	0	0
East Anglia 3	UK	1	0	0	0	0	2
Hornsea Project Three	UK	5	1	2	2	1	1
Norfolk Boreas	UK	0	0	0	0	0	1
Norfolk Vanguard	UK	0	0	0	0	0	2
Scenario 3							
N-10	DE	0	0	0	0	0	0
N-11	DE	0	0	0	0	0	0
N-12	DE	0	0	0	0	0	0
N-13	DE	0	0	0	0	0	0
N-8.4	DE	0	0	0	0	0	0
N-9.1 TF2	DE	0	0	0	0	0	0
N-9.2	DE	0	0	0	0	0	0
North East Ijmuiden	NL	0	0	0	0	0	0
North North Wadden	NL	0	0	0	0	0	0

C.3 - variant 3

wind farm	country	dec-jan	feb-mar	apr-may	jun-jul	aug-sep	oct-nov
Scenario 1							
Belwind	BE	0	0	0	0	0	0
Mermaid	BE	0	0	0	0	0	0
Norther	BE	0	0	0	0	0	0
Northwester	BE	0	0	0	0	0	0
Northwind	BE	0	0	0	0	0	0
Rentel	BE	0	0	0	0	0	0
Seastar	BE	0	0	0	0	0	0
Thorton Bank	BE	0	0	0	0	0	0
Horns Rev 3	DK	0	0	0	0	0	0
Vesterhavet Nord/Syd	DK	0	0	0	0	0	0
N-0.1	DE	0	0	0	0	0	0
N-0.2	DE	0	0	0	0	0	0
N-2.1	DE	0	0	0	0	0	0
N-2.2	DE	0	0	0	0	0	0
N-2.3	DE	0	0	0	0	0	0
N-2.4	DE	0	0	0	0	0	0
N-2.5	DE	0	0	0	0	0	0
N-2.6	DE	0	0	0	0	0	0
N-3.1	DE	0	0	0	0	0	0
N-3.2	DE	0	0	0	0	0	0
N-3.3	DE	0	0	0	0	0	0
N-3.4	DE	0	0	0	0	0	0
N-3.7	DE	0	0	0	0	0	0
N-4.1	DE	0	0	0	0	0	0
N-4.2	DE	0	0	0	0	0	0
N-4.3	DE	0	0	0	0	0	0
N-4.4	DE	0	0	0	0	0	0
N-5.1	DE	0	0	0	0	0	0
N-5.2	DE	0	0	0	0	0	0
N-5.3	DE	0	0	0	0	0	0
N-6.1	DE	1	0	0	0	0	0
N-6.2	DE	1	0	0	0	0	0
N-6.3	DE	0	0	0	0	0	0
N-6.3-P	DE	0	0	0	0	0	0
N-8.1	DE	0	0	0	0	0	0
N-8.2	DE	0	0	0	0	0	0
N-8.3	DE	0	0	0	0	0	0
Borssele I & II	NL	1	0	0	0	0	0
Borssele III & IV	NL	0	0	0	0	0	0

Gemini	NL	0	1	0	0	0	1
Hollandse Kust (Noord)	NL	0	0	0	0	0	0
Hollandse Kust (Zuid) I & II	NL	0	0	0	0	0	0
Hollandse Kust (Zuid) III & IV	NL	0	0	0	0	0	0
Luchterduinen	NL	0	0	0	0	0	0
OWEZ, Offshore Windpark Egmond aan Zee	NL	0	0	0	0	0	0
Prinses Amaliawindpark	NL	0	0	0	0	0	0
Beatrice BOWL	UK	0	0	0	0	0	0
Dudgeon	UK	0	0	0	0	0	0
East Anglia 1	UK	0	0	0	0	0	0
Galloper	UK	0	0	0	0	0	0
Greater Gabbard	UK	1	0	0	0	0	0
Hornsea Project One	UK	0	0	0	0	0	1
Hornsea Project Two	UK	0	0	0	0	1	1
Hywind Scotland Pilot Park	UK	0	0	0	0	0	0
Inch Cape	UK	0	0	0	0	0	0
Inner D, Racebank, Lincs, S. Shoal	UK	2	0	0	0	0	1
Kincardine	UK	0	0	0	0	0	0
London Array	UK	0	0	0	1	0	1
MORAY West	UK	0	0	0	0	0	0
MORL – Stevenson, Telford, Macoll (Moray)	UK	0	0	0	0	0	0
Neart na Gaoithe	UK	0	0	0	0	0	0
Repsol – Inchcape	UK	0	0	0	0	0	0
Seagreen – Alpha en Bravo	UK	0	0	0	0	0	0
Thanet	UK	0	0	0	1	0	0
Thanet extension	UK	0	0	0	0	0	0
Triton Knoll	UK	1	0	0	0	0	1
Scenario 2							
Fairy Bank 1	BE	0	0	0	0	0	0
Fairy Bank 2	BE	0	0	0	0	0	0
Fairy Bank 3, N2000	BE	0	0	0	0	0	0
Tender 2019	DK	0	0	0	0	0	0
Dunkerque	FR	0	0	0	0	0	0
N-1.1	DE	0	0	0	0	0	0
N-1.2	DE	0	0	0	0	0	0
N-1.3	DE	0	0	0	0	0	0
N-3.5	DE	0	0	0	0	0	0
N-3.6	DE	0	0	0	0	0	0
N-3.7 (except Gode Wind 04)	DE	0	0	0	0	0	0
N-3.8	DE	0	0	0	0	0	0
N-6.6	DE	0	0	0	0	0	0
N-6.7	DE	0	0	0	0	0	0
N-7.1	DE	0	0	0	0	0	0
N-7.2	DE	0	0	0	0	0	0

N-9.1 TF1	DE	0	0	0	0	0	0
Hollandse Kust (West) I	NL	0	0	0	0	0	0
Hollandse Kust (West) II	NL	0	0	0	0	0	0
Ijmuiden Ver I	NL	0	0	0	0	0	0
Ijmuiden Ver II	NL	0	0	0	0	0	0
Ijmuiden Ver III	NL	0	0	0	0	0	0
Ijmuiden Ver IV	NL	0	0	0	0	0	0
North of Waddeneilanden	NL	0	0	0	0	0	0
Dogger Bank - Teesside A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck B	UK	0	0	0	0	0	0
Dogger Bank Sofia	UK	0	0	0	0	0	0
East Anglia 1 North	UK	0	0	0	0	0	0
East Anglia 2	UK	0	0	0	0	0	0
East Anglia 3	UK	0	0	0	0	0	1
Hornsea Project Three	UK	2	0	1	1	0	0
Norfolk Boreas	UK	0	0	0	0	0	1
Norfolk Vanguard	UK	0	0	0	0	0	1
Scenario 3							
N-10	DE	0	0	0	0	0	0
N-11	DE	0	0	0	0	0	0
N-12	DE	0	0	0	0	0	0
N-13	DE	0	0	0	0	0	0
N-8.4	DE	0	0	0	0	0	0
N-9.1 TF2	DE	0	0	0	0	0	0
N-9.2	DE	0	0	0	0	0	0
North East Ijmuiden	NL	0	0	0	0	0	0
North North Wadden	NL	0	0	0	0	0	0

C.4 - variant 4

wind farm	country	dec-jan	feb-mar	apr-may	jun-jul	aug-sep	oct-nov
Scenario 1							
Belwind	BE	0	0	0	0	0	0
Mermaid	BE	0	0	0	0	0	0
Norther	BE	0	0	0	0	0	0
Northwester	BE	0	0	0	0	0	0
Northwind	BE	0	0	0	0	0	0
Rentel	BE	0	0	0	0	0	0
Seastar	BE	0	0	0	0	0	0
Thorton Bank	BE	0	0	0	0	0	0
Horns Rev 3	DK	0	0	0	0	0	0
Vesterhavet Nord/Syd	DK	0	0	0	0	0	0
N-0.1	DE	0	0	0	0	0	0
N-0.2	DE	0	0	0	0	0	0
N-2.1	DE	0	0	0	0	0	0
N-2.2	DE	0	0	0	0	0	0
N-2.3	DE	0	0	0	0	0	0
N-2.4	DE	0	0	0	0	0	0
N-2.5	DE	0	0	0	0	0	0
N-2.6	DE	0	0	0	0	0	0
N-3.1	DE	0	0	0	0	0	0
N-3.2	DE	0	0	0	0	0	0
N-3.3	DE	0	0	0	0	0	0
N-3.4	DE	0	0	0	0	0	0
N-3.7	DE	0	0	0	0	0	0
N-4.1	DE	0	0	0	0	0	0
N-4.2	DE	0	0	0	0	0	0
N-4.3	DE	0	0	0	0	0	0
N-4.4	DE	0	0	0	0	0	0
N-5.1	DE	0	0	0	0	0	0
N-5.2	DE	0	0	0	0	0	0
N-5.3	DE	0	0	0	0	0	0
N-6.1	DE	1	0	0	0	0	0
N-6.2	DE	1	0	0	0	0	0
N-6.3	DE	0	0	0	0	0	0
N-6.3-P	DE	0	0	0	0	0	0
N-8.1	DE	0	0	0	0	0	0
N-8.2	DE	0	0	0	0	0	0
N-8.3	DE	0	0	0	0	0	0
Borssele I & II	NL	0	0	0	0	0	0
Borssele III & IV	NL	0	0	0	0	0	0

Gemini	NL	0	1	0	0	0	1
Hollandse Kust (Noord)	NL	0	0	0	0	0	0
Hollandse Kust (Zuid) I & II	NL	0	0	0	0	0	0
Hollandse Kust (Zuid) III & IV	NL	0	0	0	0	0	0
Luchterduinen	NL	0	0	0	0	0	0
OWEZ, Offshore Windpark Egmond aan Zee	NL	0	0	0	0	0	0
Prinses Amaliawindpark	NL	0	0	0	0	0	0
Beatrice BOWL	UK	0	0	0	0	0	0
Dudgeon	UK	0	0	0	0	0	0
East Anglia 1	UK	0	0	0	0	0	0
Galloper	UK	0	0	0	0	0	0
Greater Gabbard	UK	0	0	0	0	0	0
Hornsea Project One	UK	0	0	0	0	0	1
Hornsea Project Two	UK	0	0	0	0	0	1
Hywind Scotland Pilot Park	UK	0	0	0	0	0	0
Inch Cape	UK	0	0	0	0	0	0
Inner D, Racebank, Lincs, S. Shoal	UK	1	0	0	0	0	1
Kincardine	UK	0	0	0	0	0	0
London Array	UK	0	0	0	0	0	1
MORAY West	UK	0	0	0	0	0	0
MORL – Stevenson, Telford, Macoll (Moray)	UK	0	0	0	0	0	0
Neart na Gaoithe	UK	0	0	0	0	0	0
Repsol – Inchcape	UK	0	0	0	0	0	0
Seagreen – Alpha en Bravo	UK	0	0	0	0	0	0
Thanet	UK	0	0	0	0	0	0
Thanet extension	UK	0	0	0	0	0	0
Triton Knoll	UK	1	0	0	0	0	1
Scenario 2							
Fairy Bank 1	BE	0	0	0	0	0	0
Fairy Bank 2	BE	0	0	0	0	0	0
Fairy Bank 3, N2000	BE	0	0	0	0	0	0
Tender 2019	DK	0	0	0	0	0	0
Dunkerque	FR	0	0	0	0	0	0
N-1.1	DE	0	0	0	0	0	0
N-1.2	DE	0	0	0	0	0	0
N-1.3	DE	0	0	0	0	0	0
N-3.5	DE	0	0	0	0	0	0
N-3.6	DE	0	0	0	0	0	0
N-3.7 (except Gode Wind 04)	DE	0	0	0	0	0	0
N-3.8	DE	0	0	0	0	0	0
N-6.6	DE	0	0	0	0	0	0
N-6.7	DE	0	0	0	0	0	0
N-7.1	DE	0	0	0	0	0	0
N-7.2	DE	0	0	0	0	0	0

N-9.1 TF1	DE	0	0	0	0	0	0
Hollandse Kust (West) I	NL	0	0	0	0	0	0
Hollandse Kust (West) II	NL	0	0	0	0	0	0
Ijmuiden Ver I	NL	0	0	0	0	0	0
Ijmuiden Ver II	NL	0	0	0	0	0	0
Ijmuiden Ver III	NL	0	0	0	0	0	0
Ijmuiden Ver IV	NL	0	0	0	0	0	0
North of Waddeneilanden	NL	0	0	0	0	0	0
Dogger Bank - Teesside A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck B	UK	0	0	0	0	0	0
Dogger Bank Sofia	UK	0	0	0	0	0	0
East Anglia 1 North	UK	0	0	0	0	0	0
East Anglia 2	UK	0	0	0	0	0	0
East Anglia 3	UK	0	0	0	0	0	1
Hornsea Project Three	UK	2	0	1	1	0	0
Norfolk Boreas	UK	0	0	0	0	0	0
Norfolk Vanguard	UK	0	0	0	0	0	1
Scenario 3							
N-10	DE	0	0	0	0	0	0
N-11	DE	0	0	0	0	0	0
N-12	DE	0	0	0	0	0	0
N-13	DE	0	0	0	0	0	0
N-8.4	DE	0	0	0	0	0	0
N-9.1 TF2	DE	0	0	0	0	0	0
N-9.2	DE	0	0	0	0	0	0
North East Ijmuiden	NL	0	0	0	0	0	0
North North Wadden	NL	0	0	0	0	0	0

Appendix D – Number of displaced individuals of common guillemot per wind farm

wind farm	coun-try	dec-jan	feb-mar	apr-may	jun-jul	aug-sep	oct-nov
Scenario 1							
Belwind	BE	483	350	10	0	1	98
Mermaid	BE	208	220	4	0	0	27
Norther	BE	535	310	1	0	0	219
Northwester	BE	296	246	6	0	0	23
Northwind	BE	298	203	8	0	3	290
Rentel	BE	494	222	4	0	4	501
Seastar	BE	273	234	9	0	4	231
Thorton Bank	BE	525	179	3	0	0	471
Horns Rev 3	DK	151	126	35	374	226	332
Vesterhavet Nord/Syd	DK	224	44	31	570	241	59
N-0.1	DE	196	118	10	1	5	428
N-0.2	DE	14	0	0	0	0	65
N-2.1	DE	320	901	72	0	82	302
N-2.2	DE	1,030	1,485	240	6	198	390
N-2.3	DE	1,140	1,629	290	16	186	522
N-2.4	DE	573	1,422	28	1	271	648
N-2.5	DE	724	1,811	97	15	289	917
N-2.6	DE	1,311	2,886	213	0	208	852
N-3.1	DE	1,484	247	45	0	629	277
N-3.2	DE	781	545	0	0	567	216
N-3.3	DE	720	294	30	0	58	825
N-3.4	DE	1,205	978	79	0	2,457	643
N-3.7	DE	1,006	422	43	0	835	311
N-4.1	DE	182	383	105	15	34	522
N-4.2	DE	309	362	78	14	194	310
N-4.3	DE	418	372	29	50	1,372	253
N-4.4	DE	879	768	126	37	958	489
N-5.1	DE	1,374	170	24	651	245	2,117
N-5.2	DE	368	0	24	40	303	1,703
N-5.3	DE	541	718	226	1,500	668	431
N-6.1	DE	100	34	30	578	3,077	103
N-6.2	DE	66	5	14	275	1,730	82
N-6.3	DE	24	3	4	259	634	48
N-6.3-P	DE	3	0	1	32	79	6
N-8.1	DE	690	18	8	7,163	3,580	91
N-8.2	DE	645	237	16	7,538	2,123	73
N-8.3	DE	174	6	2	2,859	2,506	58

Borssele I & II	NL	1,043	731	75	0	7	848
Borssele III & IV	NL	1,147	1,017	70	0	17	879
Gemini	NL	2,609	1,863	688	3,988	2,634	2,742
Hollandse Kust (Noord)	NL	1,618	874	323	1	117	1,706
Hollandse Kust (Zuid) I & II	NL	1,991	421	377	0	7	882
Hollandse Kust (Zuid) III & IV	NL	1,935	258	173	2	10	901
Luchterduinen	NL	405	58	28	0	2	117
OWEZ	NL	1,206	257	38	0	30	522
Prinses Amaliawindpark	NL	526	324	134	0	20	811
Beatrice BOWL	UK	21,150	325	1,541	8,344	245	120
Dudgeon	UK	68	470	617	806	2,391	408
East Anglia 1	UK	780	325	1,010	1,851	72	263
Galloper	UK	357	440	153	831	11	92
Greater Gabbard	UK	356	404	72	795	19	121
Hornsea Project One	UK	3,355	5,896	1,787	5,064	3,302	1,842
Hornsea Project Two	UK	3,157	6,943	1,798	4,811	4,037	1,885
Hywind Scotland Pilot Park	UK	9	301	41	264	3,012	54
Inch Cape	UK	1,660	786	1,291	5,196	13,514	453
Inner Dowsing	UK	12	191	120	996	183	85
Kincardine	UK	115	894	633	407	1,125	299
Lincs	UK	38	433	279	2,066	458	192
London Array	UK	606	114	5	0	4	123
MORAY West	UK	11,961	1,314	2,171	4,802	52	514
MORL – Stev., Tel., Mac. (Moray)	UK	12,914	2,355	2,744	8,516	228	231
Neart na Gaoithe	UK	2,136	313	2,635	1,555	6,375	230
Racebank	UK	238	512	349	990	1,228	281
Repsol – Inchcape	UK	1,859	881	1,446	5,820	15,136	508
Seagreen – Alpha en Bravo	UK	1,031	4,026	17,738	10,307	19,506	592
Sheringham Shoal	UK	101	207	538	584	677	268
Thanet	UK	289	107	6	0	10	83
Thanet extension	UK	447	173	9	0	23	119
Triton Knoll	UK	615	1,606	479	4,283	2,172	326
Scenario 2							
Fairy Bank 1	BE	793	1,273	196	0	33	326
Fairy Bank 2	BE	1,353	1,225	171	0	0	264
Fairy Bank 3, N2000	BE	1,940	1,052	89	0	0	187
Tender 2019	DK	514	134	45	832	350	524
Dunkerque	FR	1,053	1,784	4	0	0	533
N-1.1	DE	5,789	1,271	651	3,526	1,459	2,197
N-1.2	DE	5,952	1,652	893	3,232	1,430	2,306
N-1.3	DE	5,447	977	518	2,122	567	1,690
N-3.5	DE	2,184	1,271	110	0	250	1,474
N-3.6	DE	760	2,581	658	0	0	1,581
N-3.7 (except Gode Wind 04)	DE	1,347	566	57	0	1,118	416

N-3.8	DE	2,223	1,623	50	0	412	625
N-6.6	DE	289	17	51	1,016	3,999	170
N-6.7	DE	81	40	33	946	2,856	142
N-7.1	DE	1,238	2,543	188	3,225	7,837	371
N-7.2	DE	2,390	1,801	393	5,689	4,262	763
N-9.1 TF1	DE	21	122	43	1,963	1,049	82
Hollandse Kust (West) I	NL	818	655	158	1	67	1,064
Hollandse Kust (West) II	NL	990	838	108	3	42	1,089
Ijmuiden Ver I	NL	1,437	1,296	454	17	248	1,023
Ijmuiden Ver II	NL	1,676	1,258	1,082	9	274	1,316
Ijmuiden Ver III	NL	1,259	1,399	928	67	575	947
Ijmuiden Ver IV	NL	1,766	1,168	1,401	114	374	1,321
North of Waddeneilanden	NL	2,789	2,753	1,505	5,793	4,556	2,864
Dogger Bank - Teesside A	UK	870	1,804	2,107	411	512	1,266
Dogger Bank Creyke Beck A	UK	608	7,453	1,480	4,304	6,941	2,697
Dogger Bank Creyke Beck B	UK	652	23,003	1,993	2,984	1,155	4,717
Dogger Bank Sofia	UK	662	10,429	1,875	778	363	13,598
East Anglia 1 North	UK	1,102	245	1,411	2,841	66	401
East Anglia 2	UK	604	194	795	2,518	45	161
East Anglia 3	UK	3,759	977	986	472	463	706
Hornsea Project Three	UK	5,850	3,816	1,744	3,465	5,494	967
Norfolk Boreas	UK	1,562	978	1,650	78	449	3,504
Norfolk Vanguard	UK	3,759	1,269	2,142	414	1,568	1,078
Scenario 3							
N-10	DE	262	115	38	3,892	8,248	506
N-11	DE	2,671	2,356	87	37,524	23,537	1,640
N-12	DE	1,136	1,273	114	13,625	9,950	948
N-13	DE	1,101	2,418	877	10,052	16,766	2,200
N-8.4	DE	756	18	7	9,580	8,488	194
N-9.1 TF2	DE	14	81	29	1,309	699	54
N-9.2	DE	29	322	18	3,087	1,288	83
North East Ijmuiden	NL	2,018	861	1,418	56	712	1,861
North North Wadden	NL	583	211	167	2,106	3,321	475

Appendix E – Number of displaced individuals of red-throated diver per wind farm

wind farm	country	dec-jan	feb-mar	apr-may	jun-jul	aug-sep	oct-nov
Scenario 1							
Belwind	BE	0	10	0	0	0	0
Mermaid	BE	0	4	0	0	0	0
Norther	BE	205	43	0	0	0	28
Northwester	BE	0	6	0	0	0	0
Northwind	BE	2	6	0	0	0	7
Rentel	BE	17	21	0	0	0	6
Seastar	BE	0	8	0	0	0	5
Thorton Bank	BE	37	32	0	0	0	11
Horns Rev 3	DK	375	153	501	0	0	72
Vesterhavet Nord/Syd	DK	66	31	268	0	0	0
N-0.1	DE	699	43	249	0	0	520
N-0.2	DE	333	75	24	0	2	67
N-2.1	DE	0	0	40	0	0	0
N-2.2	DE	3	10	73	0	0	0
N-2.3	DE	3	10	84	0	0	0
N-2.4	DE	0	4	126	0	0	4
N-2.5	DE	0	4	146	0	0	8
N-2.6	DE	0	0	79	0	0	0
N-3.1	DE	5	40	64	0	0	8
N-3.2	DE	0	159	12	0	0	17
N-3.3	DE	0	0	87	0	0	1
N-3.4	DE	23	567	114	0	0	2
N-3.7	DE	5	157	53	0	0	3
N-4.1	DE	718	84	142	0	0	183
N-4.2	DE	934	275	24	0	0	66
N-4.3	DE	1,532	1,384	35	0	0	5
N-4.4	DE	4,076	2,940	27	0	0	80
N-5.1	DE	141	271	1,764	0	0	37
N-5.2	DE	736	195	4,205	0	0	328
N-5.3	DE	36	215	3,712	0	0	363
N-6.1	DE	0	222	16	0	0	7
N-6.2	DE	0	179	34	0	0	17
N-6.3	DE	0	89	31	0	0	15
N-6.3-P	DE	0	11	4	0	0	2
N-8.1	DE	0	11	0	0	0	0
N-8.2	DE	0	2	0	0	0	0
N-8.3	DE	0	4	0	0	0	0

Borssele I & II	NL	21	137	27	0	0	4
Borssele III & IV	NL	8	30	23	0	0	1
Gemini	NL	8	22	136	0	0	13
Hollandse Kust (Noord)	NL	7	42	98	0	0	8
Hollandse Kust (Zuid) I & II	NL	12	14	1	0	0	4
Hollandse Kust (Zuid) III & IV	NL	19	17	4	0	0	8
Luchterduinen	NL	3	1	3	0	0	3
OWEZ, Offshore Windpark Egmond aan Zee	NL	100	85	33	0	0	17
Prinses Amaliawindpark	NL	4	5	38	0	0	1
Beatrice BOWL	UK	0	0	0	0	0	15
Dudgeon	UK	0	19	42	0	0	37
East Anglia 1	UK	11	17	31	0	0	0
Galloper	UK	0	39	0	0	0	0
Greater Gabbard	UK	0	38	0	0	0	0
Hornsea Project One	UK	0	0	0	0	0	0
Hornsea Project Two	UK	0	0	0	0	0	0
Hywind Scotland Pilot Park	UK	0	0	0	0	0	0
Inch Cape	UK	0	0	0	0	0	0
Inner Dowsing	UK	19	110	0	0	0	33
Kincardine	UK	0	0	0	0	0	0
Lincs	UK	32	210	0	0	0	56
London Array	UK	29	407	25	0	0	53
MORAY West	UK	0	0	0	0	0	58
MORL – Stevenson, Telford, Macoll (Moray)	UK	0	0	0	0	0	24
Neart na Gaoithe	UK	0	0	0	0	0	0
Racebank	UK	9	371	0	0	0	40
Repsol – Inchcape	UK	0	0	0	0	0	0
Seagreen – Alpha en Bravo	UK	0	0	0	2	0	0
Sheringham Shoal	UK	0	77	46	0	0	57
Thanet	UK	44	156	25	0	0	21
Thanet extension	UK	61	178	27	0	0	31
Triton Knoll	UK	17	87	0	0	0	63
Scenario 2							
Fairy Bank 1	BE	0	26	152	0	0	6
Fairy Bank 2	BE	3	20	97	0	0	97
Fairy Bank 3, N2000	BE	5	18	0	0	0	179
Tender 2019	DK	182	126	519	0	0	43
Dunkerque	FR	153	684	14	0	0	24
N-1.1	DE	45	29	37	0	0	22
N-1.2	DE	43	66	35	0	0	21
N-1.3	DE	39	44	65	0	0	4
N-3.5	DE	0	0	226	0	0	46
N-3.6	DE	0	0	44	0	0	25
N-3.7 (except Gode Wind 04)	DE	5	237	68	0	0	4

N-3.8	DE	0	0	185	0	0	49
N-6.6	DE	0	80	52	0	0	39
N-6.7	DE	0	805	76	0	0	28
N-7.1	DE	0	102	9	0	0	3
N-7.2	DE	0	39	2	0	0	2
N-9.1 TF1	DE	0	830	34	0	0	5
Hollandse Kust (West) I	NL	1	1	0	0	0	0
Hollandse Kust (West) II	NL	4	1	0	0	0	3
Ijmuiden Ver I	NL	0	0	0	0	0	2
Ijmuiden Ver II	NL	0	0	0	0	0	2
Ijmuiden Ver III	NL	14	2	5	0	0	3
Ijmuiden Ver IV	NL	0	3	2	0	0	0
North of Waddeneilanden	NL	5	25	177	0	0	4
Dogger Bank - Teesside A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck A	UK	0	0	0	0	0	0
Dogger Bank Creyke Beck B	UK	0	0	0	0	0	0
Dogger Bank Sofia	UK	0	0	0	0	0	0
East Anglia 1 North	UK	80	20	76	0	0	0
East Anglia 2	UK	39	12	27	0	0	0
East Anglia 3	UK	2	2	28	0	0	0
Hornsea Project Three	UK	0	0	0	0	0	2
Norfolk Boreas	UK	0	41	29	0	0	18
Norfolk Vanguard	UK	17	0	191	0	0	18
Scenario 3							
N-10	DE	0	106	0	0	0	0
N-11	DE	0	0	35	0	0	0
N-12	DE	0	0	0	0	0	0
N-13	DE	0	168	6,005	0	0	0
N-8.4	DE	0	19	1	0	0	0
N-9.1 TF2	DE	0	553	23	0	0	3
N-9.2	DE	0	1,040	25	0	0	0
North East Ijmuiden	NL	0	14	48	0	0	0
North North Wadden	NL	1	68	43	0	0	11