Appendix B – Band Model Inputs and Outputs

The following pages present the outputs of a model used to assess collision risk of birds through wind farms. The results were generated by BOEM in August 2022 using a revised version of the Band (2012) model. Two scenarios were assessed for each of the three ESA-listed bird species included in this BA: 1) 100, 8-MW turbines, and 2) 74, 12-MW turbines. Refer to the first sheet of each output for the details of the model inputs. The second sheet presents the overall collision risk applying the number of bird transits, flight timing, flight height distribution, and avoidance rates. The results for each bird species are summarized in Section 4.1.1.4 of the BA.

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources	Source
Bird data				
Species name		**Piping plover**		
Bird length	m	0.17		https://en.wikipedia.org/wiki/Piping_plover (averaged 15-19 cm)
Wingspan	m	0.38		https://en.wikipedia.org/wiki/Piping_plover (averaged 35-41 cm)
Flight speed	m/sec	9.3		Stantial & Cohen 2015
Nocturnal activity factor (1-5)		4		Loring et al 2019, Fig 66; value = 4
Flight type, flapping or gliding		flapping		

Bird survey data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km														
Proportion at rotor height	%														
Proportion of flights upwind	%	8.6%													

Birds on migration data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Migration passages	birds					171	171	171		855						Adult & fledgings derived from USFWS 2022, P.Loring et al 2019
Width of migration corridor	km	38														assume all pass through lease
Proportion at rotor height	%	15%														Loring et al 2019, Table 26
Proportion of flights upwind	%	8.6%														Loring et al 2019, Fig 72

	Units	Value	Data sources	
Windfarm data				
Name of windfarm site		**RWF**		
Latitude	degrees	41.00		
Number of turbines		100		COP
Width of windfarm	km	38		Measured from COP Figure 4.2.3-8
Tidal offset	m	1		

	Units	Value	Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Turbine data																
Turbine model		**8 MW**														COP
No of blades		3														COP
Rotation speed	rpm	10.5														MHI Vestas V164-8MW, average rmp, cutin speed 4 m/s
Rotor radius	m	82														COP, Figure 3.3.8-1 & Table 3.3.8-1
Hub height	m	115														COP, Figure 3.3.8-1 & Table 3.3.8-1
Monthly proportion of time operational	%			94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	Whitney Marsh email 8/8/22
Max blade width	m	5.000														COP, Table 3.3.8-1
Pitch	degrees	1														

Avoidance rates used in presenting results			Data sources (if applicable)
	95.00%	X	Hatch & Brault 2007
	98.00%	X	Hatch & Brault 2007, Stantial 2014
	99.00%	X	Hatch & Brault 2007
	99.50%		

COLLISION RISK ASSESSMENT (BIRDS ON MIGRATION)

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!
other than to choose option for final tables

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		Piping plover
Flight speed	m/sec	9.3
Flight type		flapping

Windfarm data:

Number of turbines		100
Rotor radius	m	82
Minimum height of rotor	m	115
Total rotor frontal area	sq m	2112407

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%	94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	90.3%
Stage A - flight activity														**per annum**
Migration passages		0	0	171	171	171	0	855	0	0	0	0	0	**1368**
Migrant flux density	birds/ km	0	0	4.5	4.5	4.5	0	22.5	0	0	0	0	0	
Proportion at rotor height	%	15%												
Flux factor		0	0	58	58	58	0	290	0	0	0	0	0	
Option 1 -Basic model - Stages B, C and D														
Potential bird transits through rotors		0	0	9	9	9	0	44	0	0	0	0	0	**70**
Collision risk for single rotor transit	(from sheet 3)	4.5%												
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**3**
Option 2-Basic model using proportion from flight distribution		**0**	**0**	**1**	**1**	**1**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**5**
Option 3-Extended model using flight height distribution														
Proportion at rotor height	(from sheet 4)	27.5%												
Potential bird transits through rotors	Flux integral	0.3156	0	0	18	18	18	0	91	0	0	0	0	0	**146**
Collisions assuming no avoidance	Collision integral	0.01809	**0**	**0**	**1**	**1**	**1**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**7**
Average collision risk for single rotor transit		5.7%												
Stage E - applying avoidance rates														
Using which of above options?	**Option 3**	0.00%	0	0	1	1	1	0	5	0	0	0	0	0	**7**
Collisions assuming avoidance rate	birds per month or year	95.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collisions after applying large array correction															

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources	Source
Bird data				
Species name		**Piping plover**		
Bird length	m	0.17		https://en.wikipedia.org/wiki/Piping_plover (averaged 15-19 cm)
Wingspan	m	0.38		https://en.wikipedia.org/wiki/Piping_plover (averaged 35-41 cm)
Flight speed	m/sec	9.3		Stantial & Cohen 2015
Nocturnal activity factor (1-5)		4		Loring et al 2019, Fig 66; value = 4
Flight type, flapping or gliding		flapping		

Bird survey data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km														
Proportion at rotor height	%														
Proportion of flights upwind	%	8.6%													

Birds on migration data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Migration passages	birds					171	171	171		855						Adult & fledgings derived from USFWS 2022, P.Loring et al 2019
Width of migration corridor	km	38														assume all pass through lease
Proportion at rotor height	%	15%														Loring et al 2019, Table 26
Proportion of flights upwind	%	8.6%														Loring et al 2019, Fig 72

	Units	Value	Data sources	Source
Windfarm data				
Name of windfarm site		**RWF**		
Latitude	degrees	41.00		
Number of turbines		74		COP
Width of windfarm	km	38		Measured from COP Figure 4.2.3-8
Tidal offset	m	1		

Turbine data	Units	Value	Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Source
Turbine model		**12 MW**														COP
No of blades		3														COP
Rotation speed	rpm	7.8														average rmp, cutin speed 4 m/s
Rotor radius	m	110														COP, Figure 3.3.8-1 & Table 3.3.8-1
Hub height	m	156														COP, Figure 3.3.8-1 & Table 3.3.8-1
Monthly proportion of time operational	%			94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	Whitney Marsh email 8/8/22
Max blade width	m	8.000														COP, Table 3.3.8-1
Pitch	degrees	1														

Avoidance rates used in presenting results			Data sources (if applicable)
	95.00%	X	Hatch & Brault 2007
	98.00%	X	Hatch & Brault 2007, Stantial 2014
	99.00%	X	Hatch & Brault 2007
	99.50%		

COLLISION RISK ASSESSMENT (BIRDS ON MIGRATION)

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!
other than to choose option for final tables

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		Piping plover
Flight speed	m/sec	9.3
Flight type		flapping

Windfarm data:

Number of turbines		74
Rotor radius	m	110
Minimum height of rotor	m	156
Total rotor frontal area	sq m	2812982

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	90.3%
Stage A - flight activity															**per annum**
Migration passages			0	0	171	171	171	0	855	0	0	0	0	0	**1368**
Migrant flux density	birds/ km		0	0	4.5	4.5	4.5	0	22.5	0	0	0	0	0	
Proportion at rotor height	%	15%													
Flux factor			0	0	58	58	58	0	288	0	0	0	0	0	
Option 1 -Basic model - Stages B, C and D															
Potential bird transits through rotors			0	0	9	9	9	0	44	0	0	0	0	0	**70**
Collision risk for single rotor transit	(from sheet 3)	5.0%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**3**
Option 2-Basic model using proportion from flight distribution			**0**	**0**	**1**	**1**	**1**	**0**	**4**	**0**	**0**	**0**	**0**	**0**	**6**
Option 3-Extended model using flight height distribution															
Proportion at rotor height	(from sheet 4)	32.4%													
Potential bird transits through rotors	Flux integral	0.3552	0	0	20	20	20	0	102	0	0	0	0	0	**163**
Collisions assuming no avoidance	Collision integral	0.02146	**0**	**0**	**1**	**1**	**1**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**9**
Average collision risk for single rotor transit		6.0%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 3**	0.00%	0	0	1	1	1	0	5	0	0	0	0	0	**9**
	birds per month														
Collisions assuming avoidance rate	or year	95.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collisions after applying large array correction		95.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources	Source
Bird data				
Species name		**Roseate tern**		
Bird length	m	0.35		https://en.wikipedia.org/wiki/Roseate_tern (averaged 33-36 cm)
Wingspan	m	0.72		https://en.wikipedia.org/wiki/Roseate_tern (averaged 67-76 cm)
Flight speed	m/sec	10.4		https://birdsna.org/Species-Account/bna/species/roster/behavior#locom
Nocturnal activity factor (1-5)		1		Table A-8, Robinson Willmott et al., 2013 value = 1 (PL data confirms)
Flight type, flapping or gliding		flapping		

Bird survey data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km														
Proportion at rotor height	%	6.0%													
Proportion of flights upwind	%	37.5%													

Birds on migration data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Source
Migration passages	birds						4331	4331	817	817	8657	8657				Adult, fledglings, non-breeding, numbers devived from Mostello unpub data & Nisbet et al 2014
Width of migration corridor	km	135														Migration front is Block Island to Monomoy
Proportion at rotor height	%	6%														Loring et al 2019, Table 18 Fed waters
Proportion of flights upwind	%	37.5%														Loring et al 2019, Fig 50

Windfarm data	Units	Value	Data sources	Source
Name of windfarm site		**RWF**		
Latitude	degrees	41.00		
Number of turbines		100		COP
Width of windfarm	km	38		Measured from COP Figure 4.2.3-8
Tidal offset	m	1		

Turbine data	Units	Value	Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Source
Turbine model		**8 MW**														COP
No of blades		3														COP
Rotation speed	rpm	10.5														MHI Vestas V164-8MW, average rmp, cutin speed 4 m/s
Rotor radius	m	82														COP, Figure 3.3.8-1 & Table 3.3.8-1
Hub height	m	115														COP, Figure 3.3.8-1 & Table 3.3.8-1
Monthly proportion of time operational	%			94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	Whitney Marsh email 8/8/22
Max blade width	m	5.000														COP, Table 3.3.8-1
Pitch	degrees	1														

Avoidance rates used in presenting results			**Data sources (if applicable)**
	95.01%	X	Table A2, recommended avoid rates for all other terns, extended (2012) Band model, Cook 2021
	98.00%		
	99.00%		
	99.50%		

COLLISION RISK ASSESSMENT (BIRDS ON MIGRATION)

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!
other than to choose option for final tables

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		Roseate tern
Flight speed	m/sec	10.4
Flight type		flapping

Windfarm data:

Number of turbines		100
Rotor radius	m	82
Minimum height of rotor	m	115
Total rotor frontal area	sq m	2112407

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	90.3%
Stage A - flight activity															**per annum**
Migration passages			0	0	0	4331	4331	817	817	8657	8657	0	0	0	**27610**
Migrant flux density	birds/ km		0	0	0	32.081	32.08148	6.051852	6.051852	64.12593	64.12593	0	0	0	
Proportion at rotor height	%	6%													
Flux factor			0	0	0	413	413	78	78	826	826	0	0	0	
Option 1 -Basic model - Stages B, C and D															
Potential bird transits through rotors			0	0	0	26	26	5	5	53	53	0	0	0	**169**
Collision risk for single rotor transit	(from sheet 3)	5.5%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**0**	**0**	**0**	**1**	**1**	**0**	**0**	**2**	**3**	**0**	**0**	**0**	**8**
Option 2-Basic model using proportion from flight distribution			**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 3-Extended model using flight height distribution															
Proportion at rotor height	(from sheet 4)	0.0%													
Potential bird transits through rotors	Flux integral	0.0000	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collisions assuming no avoidance	Collision integral	0.00000	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average collision risk for single rotor transit		#DIV/0!													
Stage E - applying avoidance rates															
Using which of above options?	**Option 3**	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	birds per month														
Collisions assuming avoidance rate	or year	95.01%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collisions after applying large array correction		95.01%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources	Source
Bird data				
Species name		**Roseate tern**		
Bird length	m	0.35		https://en.wikipedia.org/wiki/Roseate_tern (averaged 33-36 cm)
Wingspan	m	0.72		https://en.wikipedia.org/wiki/Roseate_tern (averaged 67-76 cm)
Flight speed	m/sec	10.4		https://birdsna.org/Species-Account/bna/species/roster/behavior#locom
Nocturnal activity factor (1-5)		1		Table A-8, Robinson Willmott et al., 2013 value = 1 (PL data confirms)
Flight type, flapping or gliding		flapping		

Bird survey data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km														
Proportion at rotor height	%	6.0%													
Proportion of flights upwind	%	37.5%													

Birds on migration data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Source
Migration passages	birds						4331	4331	817	817	8657	8657				Adult, fledglings, non-breeding, numbers devived from Mostello unpub data & Nisbet et al 2014
Width of migration corridor	km	135														Migration front is Block Island to Monomoy
Proportion at rotor height	%	6%														Loring et al 2019, Table 18 Fed waters
Proportion of flights upwind	%	37.5%														Loring et al 2019, Fig 50

Windfarm data	Units	Value	Data sources	Source
Name of windfarm site		**RWF**		
Latitude	degrees	41.00		
Number of turbines		74		COP
Width of windfarm	km	38		Measured from COP Figure 4.2.3-8
Tidal offset	m	1		

Turbine data	Units	Value	Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Source
Turbine model		**12 MW**														COP
No of blades		3														COP
Rotation speed	rpm	7.8														average rmp, cutin speed 4 m/s
Rotor radius	m	110														COP, Figure 3.3.8-1 & Table 3.3.8-1
Hub height	m	156														COP, Figure 3.3.8-1 & Table 3.3.8-1
Monthly proportion of time operational	%			94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	Whitney Marsh email 8/8/22
Max blade width	m	8.000														COP, Table 3.3.8-1
Pitch	degrees	1														

Avoidance rates used in presenting results		**Data sources (if applicable)**
	95.01%	X Table A2, recommended avoid rates for all other terns, extended (2012) Band model, Cook 2021
	98.00%	
	99.00%	
	99.50%	

COLLISION RISK ASSESSMENT (BIRDS ON MIGRATION)

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!
other than to choose option for final tables

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		Roseate tern
Flight speed	m/sec	10.4
Flight type		flapping

Windfarm data:

Number of turbines		74
Rotor radius	m	110
Minimum height of rotor	m	156
Total rotor frontal area	sq m	2812982

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	90.3%
Stage A - flight activity															**per annum**
Migration passages			0	0	0	4331	4331	817	817	8657	8657	0	0	0	**27610**
Migrant flux density	birds/ km		0	0	0	32.081	32.08148	6.051852	6.051852	64.12593	64.12593	0	0	0	
Proportion at rotor height	%	6%													
Flux factor			0	0	0	410	410	77	77	820	820	0	0	0	
Option 1 -Basic model - Stages B, C and D															
Potential bird transits through rotors			0	0	0	26	26	5	5	52	52	0	0	0	**167**
Collision risk for single rotor transit	(from sheet 3)	5.8%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**0**	**0**	**0**	**1**	**1**	**0**	**0**	**3**	**3**	**0**	**0**	**0**	**8**
Option 2-Basic model using proportion from flight distribution			**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 3-Extended model using flight height distribution															
Proportion at rotor height	(from sheet 4)	0.0%													
Potential bird transits through rotors	Flux integral	0.0000	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collisions assuming no avoidance	Collision integral	0.00000	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average collision risk for single rotor transit		#DIV/0!													
Stage E - applying avoidance rates															
Using which of above options?	**Option 3**	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	birds per month														
Collisions assuming avoidance rate	or year	95.01%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collisions after applying large array correction		95.01%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources	Source
Bird data				
Species name		**RedKnot**		
Bird length	m	0.24		Gordon and Nations 2016, Table 3.1
Wingspan	m	0.54		Gordon and Nations 2016, Table 3.1
Flight speed	m/sec	20.1		Gordon and Nations 2016, Table 3.1
Nocturnal activity factor (1-5)		5		Table A-8, Robinson Willmott et al., 2013; Loring et al 2018
Flight type, flapping or gliding		flapping		

			Data sources											
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km													
Proportion at rotor height	%													
Proportion of flights upwind	%	34.6%												

			Data sources	
Birds on migration data				
Migration passages	birds		8	25	25	25	Fall:1500 birds*5% (Gordon and Nations 2016, Loring et al 2018); Spr: 150*5%
Width of migration corridor	km	38					assume all pass through lease
Proportion at rotor height	%	83%					Loring et al 2018, p. 60
Proportion of flights upwind	%	34.6%					Loring et al 2018, Fig. 14

	Units	Value	Data sources	Source
Windfarm data				
Name of windfarm site		**RWF**		
Latitude	degrees	41.00		
Number of turbines		100		COP
Width of windfarm	km	38		Measured from COP Figure 4.2.3-8
Tidal offset	m	1		

	Units	Value	Data sources	Source
Turbine data				
Turbine model		**8 MW**		COP
No of blades		3		COP
Rotation speed	rpm	10.5		MHI Vestas V164-8MW, average rmp, cutin speed 4 m/s
Rotor radius	m	82		COP, Figure 3.3.8-1 & Table 3.3.8-1
Hub height	m	115		COP, Figure 3.3.8-1 & Table 3.3.8-1
Max blade width	m	5.000		COP, Table 3.3.8-1
Pitch	degrees	1		

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly proportion of time operational	%		94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	Whitney Marsh email 8/8/22

Avoidance rates used in presenting results			**Data sources (if applicable)**
	95.00%		
	98.00%	X	SHN 2018
	99.00%		
	99.50%		

COLLISION RISK ASSESSMENT (BIRDS ON MIGRATION)

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!
other than to choose option for final tables

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		RedKnot
Flight speed	m/sec	20.1
Flight type		flapping

Windfarm data:

Number of turbines		100
Rotor radius	m	82
Minimum height of rotor	m	115
Total rotor frontal area	sq m	2112407

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%	94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	90.3%
Stage A - flight activity														**per annum**
Migration passages		0	0	0	0	8	0	25	25	25	0	0	0	**83**
Migrant flux density	birds/ km	0	0	0	0	0.210526	0	0.657895	0.657895	0.657895	0	0	0	
Proportion at rotor height	% 83%													
Flux factor		0	0	0	0	3	0	8	8	8	0	0	0	
Option 1 -Basic model - Stages B, C and D														
Potential bird transits through rotors		0	0	0	0	2	0	7	7	7	0	0	0	**23**
Collision risk for single rotor transit	(from sheet 3) 4.5%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
Option 2-Basic model using proportion from flight distribution		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 3-Extended model using flight height distribution														
Proportion at rotor height	(from sheet 4) 35.4%													
Potential bird transits through rotors	Flux integral 0.3155	0	0	0	0	1	0	3	3	3	0	0	0	**9**
Collisions assuming no avoidance	Collision integral 0.01091	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average collision risk for single rotor transit	3.5%													
Stage E - applying avoidance rates														
Using which of above options?	**Option 3** 0.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collisions assuming avoidance rate	birds per month or year 95.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collisions after applying large array correction	95.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources	Source
Bird data				
Species name		**RedKnot**		
Bird length	m	0.24		Gordon and Nations 2016, Table 3.1
Wingspan	m	0.54		Gordon and Nations 2016, Table 3.1
Flight speed	m/sec	20.1		Gordon and Nations 2016, Table 3.1
Nocturnal activity factor (1-5)		5		Table A-8, Robinson Willmott et al., 2013; Loring et al 2018
Flight type, flapping or gliding		flapping		

			Data sources											
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km													
Proportion at rotor height	%													
Proportion of flights upwind	%	34.6%												

			Data sources	
Birds on migration data				
Migration passages	birds		8	25	25	25	Fall:1500 birds*5% (Gordon and Nations 2016, Loring et al 2018); Spr: 150*5%
Width of migration corridor	km	38					assume all pass through lease
Proportion at rotor height	%	83%					Loring et al 2018, p. 60
Proportion of flights upwind	%	34.6%					Loring et al 2018, Fig. 14

	Units	Value	Data sources	Source
Windfarm data				
Name of windfarm site		**RWF**		
Latitude	degrees	41.00		
Number of turbines		74		COP
Width of windfarm	km	38		Measured from COP Figure 4.2.3-8
Tidal offset	m	1		

	Units	Value	Data sources												Source
Turbine data															
Turbine model		**12 MW**													COP
No of blades		3													COP
Rotation speed	rpm	7.8													average rmp, cutin speed 4 m/s
Rotor radius	m	110													COP, Figure 3.3.8-1 & Table 3.3.8-1
Hub height	m	156	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	COP, Figure 3.3.8-1 & Table 3.3.8-1
Monthly proportion of time operational	%		94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	Whitney Marsh email 8/8/22
Max blade width	m	8.000													COP, Table 3.3.8-1
Pitch	degrees	1													

Avoidance rates used in presenting results			**Data sources (if applicable)**
	95.00%		
	98.00%	X	SHN 2018
	99.00%		
	99.50%		

COLLISION RISK ASSESSMENT (BIRDS ON MIGRATION)

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!
other than to choose option for final tables

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		RedKnot
Flight speed	m/sec	20.1
Flight type		flapping

Windfarm data:

Number of turbines		74
Rotor radius	m	110
Minimum height of rotor	m	156
Total rotor frontal area	sq m	2812982

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		94%	94%	92%	91%	88%	89%	86%	85%	87%	91%	93%	94%	90.3%
Stage A - flight activity															**per annum**
Migration passages			0	0	0	0	8	0	25	25	25	0	0	0	**83**
Migrant flux density	birds/ km		0	0	0	0	0.210526	0	0.657895	0.657895	0.657895	0	0	0	
Proportion at rotor height	%	83%													
Flux factor			0	0	0	0	3	0	8	8	8	0	0	0	
Option 1 -Basic model - Stages B, C and D															
Potential bird transits through rotors			0	0	0	0	2	0	7	7	7	0	0	0	**23**
Collision risk for single rotor transit	(from sheet 3)	5.0%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
Option 2-Basic model using proportion from flight distribution			**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 3-Extended model using flight height distribution															
Proportion at rotor height	(from sheet 4)	31.9%													
Potential bird transits through rotors	Flux integral	0.2688	0	0	0	0	1	0	2	2	2	0	0	0	**8**
Collisions assuming no avoidance	Collision integral	0.01199	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average collision risk for single rotor transit		4.5%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 3**	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	birds per month														
Collisions assuming avoidance rate	or year	95.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collisions after applying large array correction		95.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.50%	0	0	0	0	0	0	0	0	0	0	0	0	**0**