March 28, 2023

Addendum to the Ocean Wind 1 Biological Assessment to USFWS

Pursuant to Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, on May 27, 2022, the Bureau of Ocean Energy Management (BOEM) requested consultation with the U.S. Fish and Wildlife Service (USFWS) regarding species that may be affected by the approval of a Construction and Operations Plan (COP) for the for the Ocean Wind 1 project, a commercial wind energy facility located within BOEM's OCS-A 0498 Lease Area offshore New Jersey.

Since the submission of the revised Biological Assessment (BA) on November 18, 2022, the Stochastic Collision Risk Assessment for Movement (SCRAM) model was very recently updated. BOEM then re-ran the SCRAM model for the piping plover, red knot, and roseate tern with the updated information. Tables 1 and 2 summarize the results of the runs. The model input file and SCRAM reports are provided as attachments to the email that transmitted this addendum.

Generally, the SCRAM results of the analyses are similar to those in the most recent BA. SCRAM predicted that the annual probability of a collision for each of the three species as very low, at <0.001 for both scenarios (Table 1) suggesting that collision with turbines is extremely unlikely. SCRAM also predicted that the average annual number of collisions was less than 1 for both scenarios (Table 1). Not surprisingly, the probability of a collision event during the 35-year operational period is also very unlikely (less than 0.5) at 0.034 for both scenarios (Table 2). The average number of collisions were less than one for piping plover and roseate terns but not for the red knot for both scenarios (Table 2).

However, the estimated number of Red Knot collisions are very likely biased high for a couple reasons: 1) SCRAM uses Red Knot population sizes that is larger than the number of birds that are likely to be transiting waters near the US Atlantic offshore leases during fall migration. A recent study found that 81% (118 out 146) of the red knots fitted with radio transmitters could transit the US Atlantic region where offshore leases are located during fall migration (Loring et al. 2020); this suggests that the fall population sizes used in SCRAM are likely biased high by 19 precent. 2) SCRAM uses population sizes and movement data to estimate the number of birds within a 50km x 50 km grid cell containing the project. In some grid cells, the modeled estimate of the number of birds can be very large. For example, in a grid cell for another project, the estimated number of birds during September exceeds the population size of 72,250 by more than 10,000 animals, thus leading to wildly inflated estimates of collisions. The grid cell that contains Ocean Wind 1 is estimated to have 40 birds in September and 158 birds in November, and thus is at the very low end of the spectrum. For these reasons, BOEM believes that the estimated number of red knot collisions are likely biased high and should be interpreted not as absolutes but as a relative number of collisions.

Based on the updated SCRAM model, BOEM's determinations in the BA (November 18, 2022) for roseate terns and piping plovers remain the same where the Proposed Action would not likely to adversely affect roseate terns and piping plovers for both scenarios. However, BOEM has revised its previous determination of NLAA for the red knot and has now determined that the Proposed Action is **likely to adversely affect** red knots.

Table 1. Annual model outputs. Values greater than one are in bold.

Scenario	Species	SCRAM Probability of collision [a]	SCRAM Collisions (95% Prediction Interval) [b]
22 m gap	Piping Plover	< 0.001	0.006 (0.000 - 0.052)
	Red Knot	< 0.001	0.075 (0.000 - 0.360)
	Roseate Tern	< 0.001	0.000 (0.000 - 0.000)
36 m gap	Piping Plover	< 0.001	0.005 (0.000 - 0.046)
	Red Knot	< 0.001	0.106 (0.000 - 0.525)
	Roseate Tern	< 0.001	0.000 (0.000 - 0.000)

[a] SCRAM report, SCRAM run details, p. 2
[b] SCRAM report, Table 9

Table 2. Life of project (35 years) - Extrapolated from model outputs. Values greater than one are in bold.

Scenario	Species	Probability of collision [a]	Collisions (95% Prediction Interval) [b]
22 m gap	Piping Plover	0.034	0.2 (0.0 - 1.8)
	Red Knot	0.034	**2.6** (0.0 - 12.6)
	Roseate Tern	0.034	0.0 (0.0 - 0.0)
36 m gap	Piping Plover	0.034	0.2 (0.0 - 1.6)
	Red Knot	0.034	**3.7** (0.0 - 18.4)
	Roseate Tern	0.034	0.0 (0.0 - 0.0)

[a] $\text{Probability}_{life} = 1-(1-\text{Probability}_{annual})^{\text{Years}}$
[b] $\text{Collisions}_{life} = \text{Collisions}_{annual} \times \text{Years}$

Summary of simulation results from SCRAM: a stochastic collision risk assessment for movement data

16 March 2023

SCRAM was developed by Biodiversity Research Institute, the University of Rhode Island, and the U.S. Fish and Wildlife Service with funding from the Bureau of Ocean Energy Management.

SCRAM run details

```
## SCRAM - the Stochastic Collision Risk Assessment for Movement version
## Version: 1.0.3 - Cathartic Adela
## Iterations: 1000
## Type of model employed: trunc
## Model option: Option 3: slower but more precise assessment
## Proportion transient in model cell: 0.857
## Project: Ocean Wind 1
## Modeler: David Bigger
## The model run was started at: Thu Mar 16 13:59:32 2023 EDT
## The model run was completed at: Thu Mar 16 14:45:37 2023 EDT
## Run 1: the probability of exceeding specified threshold (1) is < 0.001.
## Run 2: the probability of exceeding specified threshold (1) is < 0.001.
```

Model inputs used for this analysis

Table 1: Species input parameters (mean and 95 perc. range).

Species	Turbine model	Avoidance	Wing span	Body length	Speed	Upwind Prop.
Piping Plover	HalX 22m	0.93 (0.921, 0.939)	0.381 (0.381, 0.381)	0.175 (0.17, 0.18)	11.773 (3.271, 21.018)	0.086 (0.086, 0.086)
Piping Plover	HalX 36m	0.93 (0.921, 0.939)	0.381 (0.381, 0.381)	0.175 (0.17, 0.18)	11.773 (3.271, 21.018)	0.086 (0.086, 0.086)

Table 2: Species monthly (Jan-Jun) population estimates ± SD and assumptions/limitations as specified by the USFWS using the most recent data.

Species	Jan	Feb	Mar	Apr	May	Jun
Piping Plover	0 ± 0	0 ± 0	4578 ± 0	4578 ± 0	4578 ± 0	4578 ± 0

Table 3: Species monthly (Jul-Dec) population estimates ± SD and assumptions/limitations as specified by the USFWS using the most recent data.

Species	Jul	Aug	Sep	Oct	Nov	Dec
Piping Plover	4578 ± 0	7423 ± 0	7423 ± 0	7423 ± 0	0 ± 0	0 ± 0

Population data assumptions/limitations:
1) Entire Atlantic coast population could be present in area during months listed.
2) Occurrence through October to include birds stopping over in mid-Atlantic (e.g. North Carolina). Number of birds still present in Atlantic likely lower.
3) Estimate of HY fledges, uses the 20-year (2002 - 2021) average productivity (unweighted).

Table 4: Wind farm input parameters (mean and 95 perc. range).

Species	Turbine model	Num. turbines	Rotor radius	Hub height (m)	Blade width (m)	Wind speed (mps)
Piping Plover	HalX 22m	98	107 (107, 107)	129 (129, 129)	5.77 (5.77, 5.77)	7.87 (6.98, 8.71)
Piping Plover	HalX 36m	98	107 (107, 107)	143 (143, 143)	5.77 (5.77, 5.77)	7.9 (7.06, 8.72)

Table 5: Wind farm input parameters (mean and 95 perc. range).

Species	Turbine model	Rotor speed (rpm)	Pitch (radians)	Farm width (km)	Lat.	Long.
Piping Plover	HalX 22m	3.86 (3.43, 4.27)	0.06 (0.02, 0.1)	20	39.22	-74.32
Piping Plover	HalX 36m	3.88 (3.47, 4.28)	0.06 (0.02, 0.1)	20	39.22	-74.32

Table 6: Monthly (Jan-Jun) wind farm operational percentage (mean and 95 perc. range) is given for each wind farm specification.

Species	Turbine model	Jan Op.	Feb Op.	Mar Op.	Apr Op.	May Op.	Jun Op.
Piping Plover	HalX 36m	91.4 (88, 94.7)	92.5 (88.7, 96.1)	91.4 (87.7, 95.1)	91.8 (89.7, 93.9)	90.7 (87.1, 94.6)	89.6 (85.3, 93.5)
Piping Plover	HalX 22m	91.4 (88.1, 94.5)	92.5 (89, 96.3)	91.5 (87.8, 95.1)	91.8 (89.7, 93.9)	90.8 (87, 94.3)	89.6 (85.2, 94)

Table 7: Monthly (Jul-Dec) wind farm operational percentage (mean and 95 perc. range) is given for each wind farm specification.

Species	Turbine model	Jul Op.	Aug Op.	Sep Op.	Oct Op.	Nov Op.	Dec Op.
Piping Plover	HalX 36m	87.6 (83.3, 92.1)	86.2 (79.6, 92.5)	87.7 (82.4, 93.5)	89.9 (85.5, 94.5)	90.1 (85.6, 94.8)	91.4 (88.4, 94.5)
Piping Plover	HalX 22m	87.8 (83.2, 92)	86 (79.9, 92.4)	87.7 (82, 93.5)	89.9 (85.9, 94.1)	90.2 (86, 94.7)	91.4 (88.2, 94.6)

Results for the SCRAM simulation

Table 8: The populations estimate for each month and the estimated daily number of (95 perc. prediction intervals) animals in the model cell and collisions at the wind farm. Results are not shown for months that do not have movement data. This does not mean that collisions could not occur in those months, but we do not have movement data to estimate collisions during these periods.

Species	Turbine model	Month	Population estimate	Est. daily num. of animals in the model cell	Est. daily num. of collisions in the wind farm
Piping Plover	HalX 22m	Jan	0		
Piping Plover	HalX 22m	Feb	0		
Piping Plover	HalX 22m	Mar	4578		
Piping Plover	HalX 22m	Apr	4578		
Piping Plover	HalX 22m	May	4578	0 (0, 0)	0 (0, 0)
Piping Plover	HalX 22m	Jun	4578	0.01334 (0, 0)	2.29e-06 (0, 0)
Piping Plover	HalX 22m	Jul	4578	0.3548 (0, 1.337)	5.44e-05 (0, 0.000313)
Piping Plover	HalX 22m	Aug	7423	0.718 (0, 9.325)	0.000112 (0, 0.0016)
Piping Plover	HalX 22m	Sep	7423	0.159 (0, 0)	2.11e-05 (0, 0)
Piping Plover	HalX 22m	Oct	7423		
Piping Plover	HalX 22m	Nov	0		
Piping Plover	HalX 22m	Dec	0		
Piping Plover	HalX 36m	Jan	0		
Piping Plover	HalX 36m	Feb	0		
Piping Plover	HalX 36m	Mar	4578		
Piping Plover	HalX 36m	Apr	4578		
Piping Plover	HalX 36m	May	4578	0 (0, 0)	0 (0, 0)
Piping Plover	HalX 36m	Jun	4578	0.01334 (0, 0)	1.85e-06 (0, 0)
Piping Plover	HalX 36m	Jul	4578	0.3548 (0, 1.337)	4.79e-05 (0, 0.000288)
Piping Plover	HalX 36m	Aug	7423	0.718 (0, 9.325)	9.34e-05 (0, 0.00139)
Piping Plover	HalX 36m	Sep	7423	0.159 (0, 0)	1.76e-05 (0, 0)
Piping Plover	HalX 36m	Oct	7423		
Piping Plover	HalX 36m	Nov	0		
Piping Plover	HalX 36m	Dec	0		

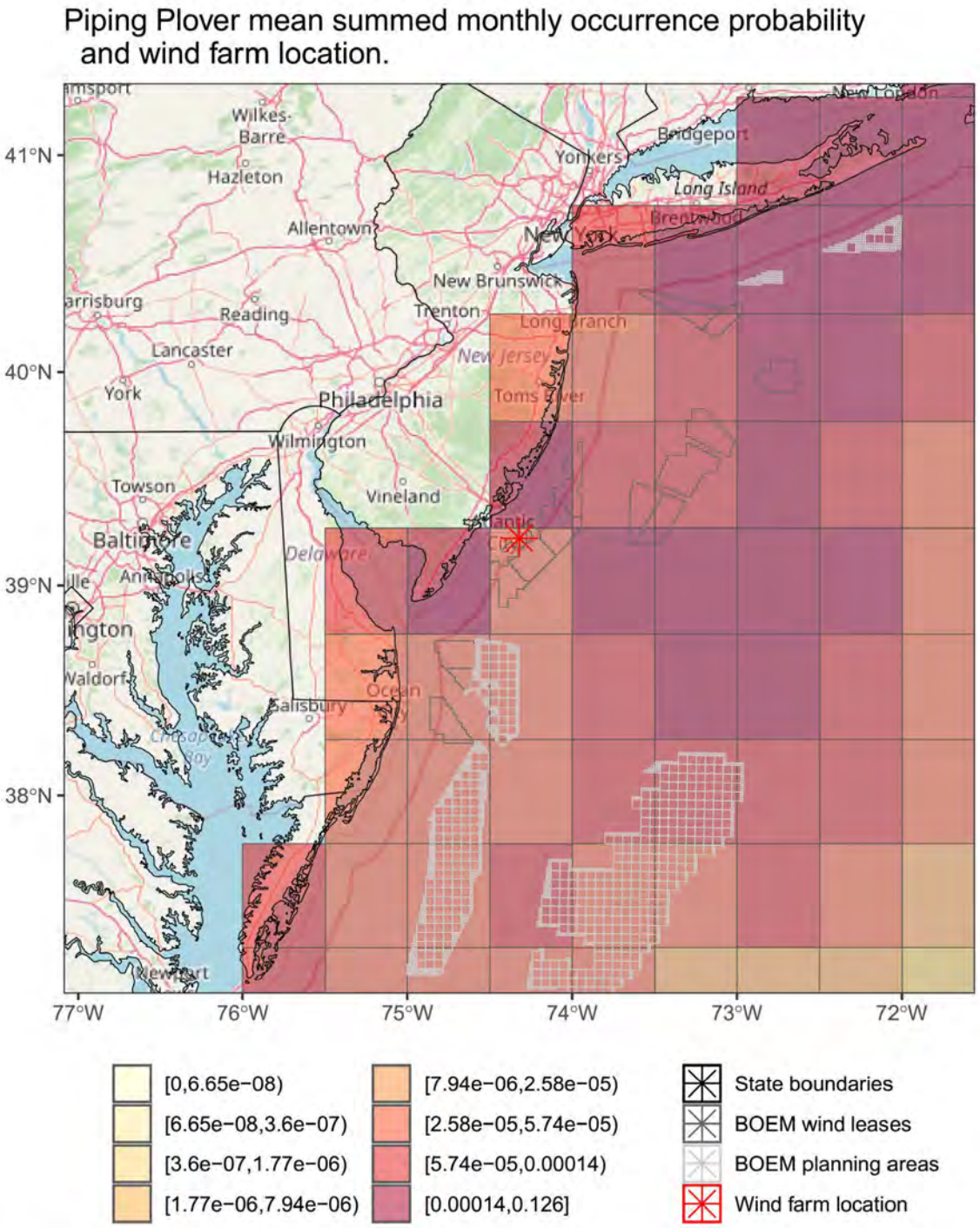

Figure 1: A map of the mean monthly species occurrence probabilities (i.e., the mean of all summed daily occurrence probabilities across all months) and wind farm location. Collision estimates use summed daily occurrence probability rather than these values as shown; the values in this figure are presented for display purposes only to show relative differences in occurrence across the area of interest.

Table 9: The estimated monthly number (95 perc. prediction intervals) of collisions. Results are not shown for months that do not have movement data and does not mean that collisions could not occur in those months.

Species	Turbine model	month	Est. num. of collisions
Piping Plover	HalX 22m	Jan	
Piping Plover	HalX 22m	Feb	
Piping Plover	HalX 22m	Mar	
Piping Plover	HalX 22m	Apr	
Piping Plover	HalX 22m	May	2.1e-05 (0, 3e-05)
Piping Plover	HalX 22m	Jun	8.96e-05 (0, 3e-05)
Piping Plover	HalX 22m	Jul	0.00171 (0, 0.0097)
Piping Plover	HalX 22m	Aug	0.00348 (0, 0.0496)
Piping Plover	HalX 22m	Sep	0.000654 (0, 3e-05)
Piping Plover	HalX 22m	Oct	
Piping Plover	HalX 22m	Nov	
Piping Plover	HalX 22m	Dec	
Piping Plover	HalX 36m	Jan	
Piping Plover	HalX 36m	Feb	
Piping Plover	HalX 36m	Mar	
Piping Plover	HalX 36m	Apr	
Piping Plover	HalX 36m	May	2.1e-05 (0, 3e-05)
Piping Plover	HalX 36m	Jun	7.65e-05 (0, 3e-05)
Piping Plover	HalX 36m	Jul	0.00151 (0, 0.00893)
Piping Plover	HalX 36m	Aug	0.00292 (0, 0.043)
Piping Plover	HalX 36m	Sep	0.000549 (0, 3e-05)
Piping Plover	HalX 36m	Oct	
Piping Plover	HalX 36m	Nov	
Piping Plover	HalX 36m	Dec	
Piping Plover	HalX 22m	Annual	0.00595 (0.00015, 0.0527)
Piping Plover	HalX 36m	Annual	0.00507 (0.00015, 0.0462)

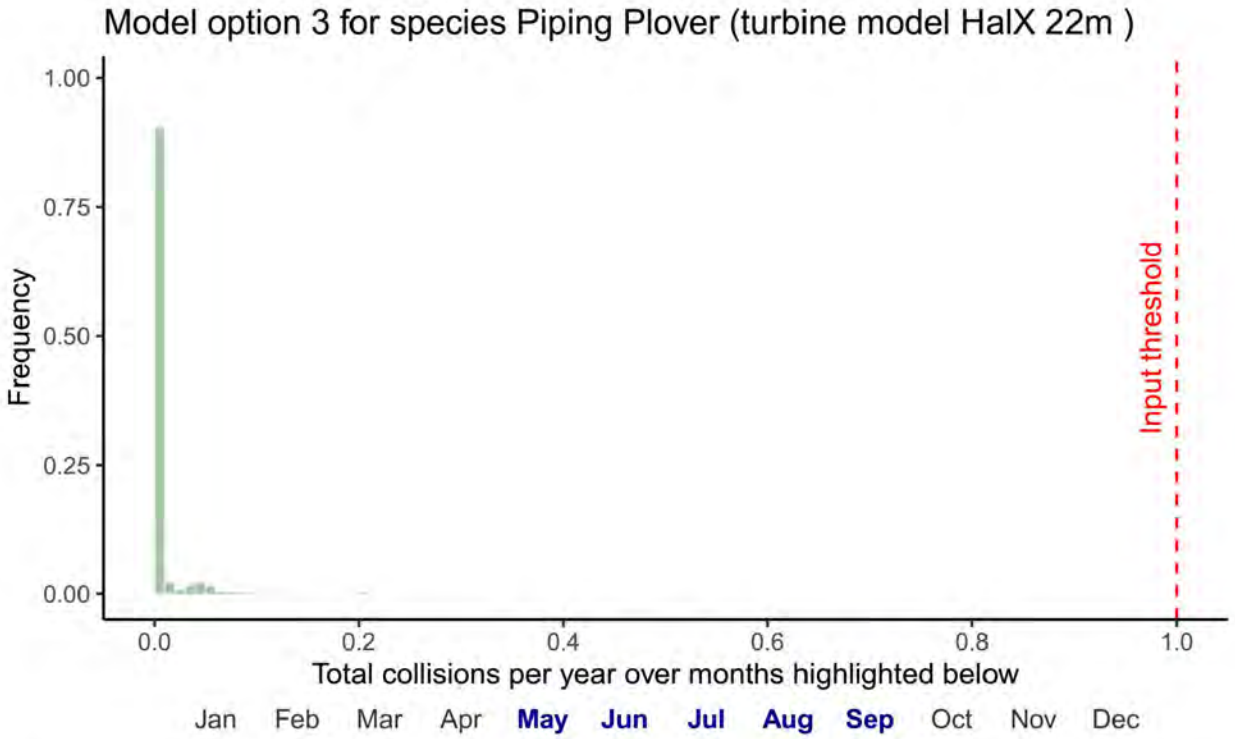

Figure 2: A frequency histogram of the total number of collisions per year. The heights of the bars show the relative frequency of each value. Months for which movement data were provided or available are shown in bold; only bold months are shown in histogram of annual collisions.

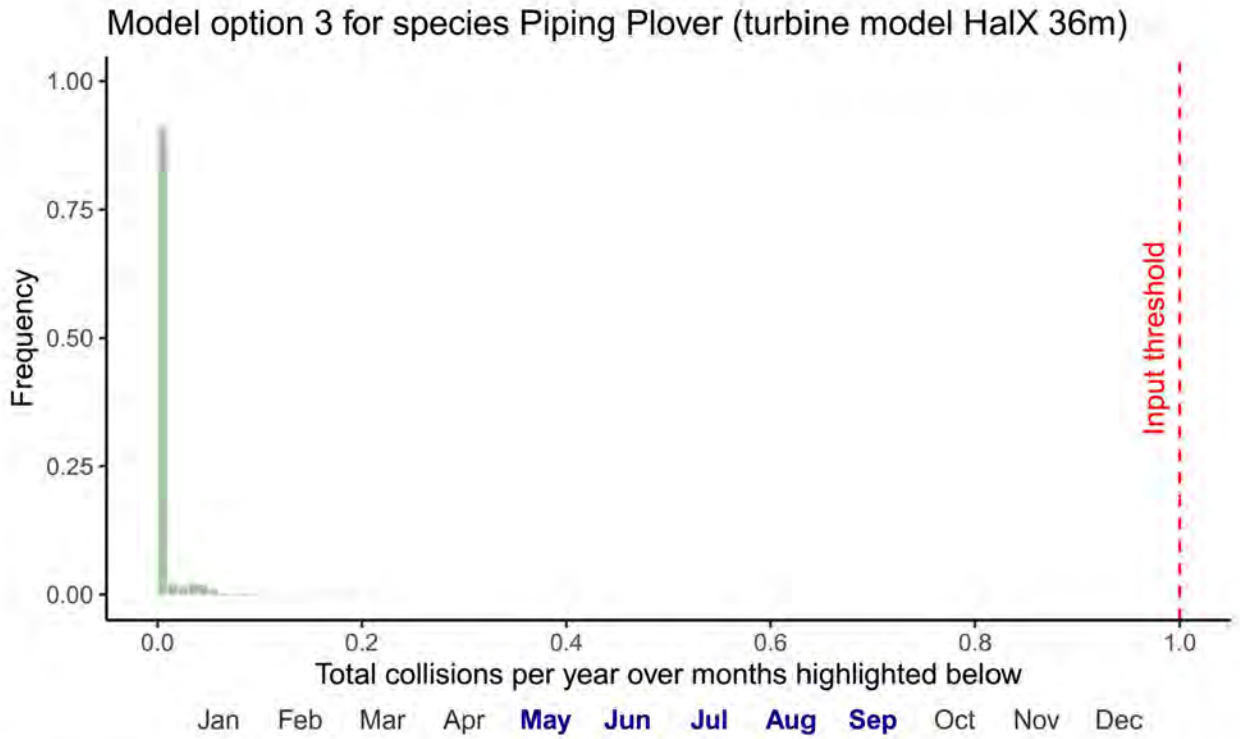

Figure 3: A frequency histogram of the total number of collisions per year. The heights of the bars show the relative frequency of each value. Months for which movement data were provided or available are shown in bold; only bold months are shown in histogram of annual collisions.

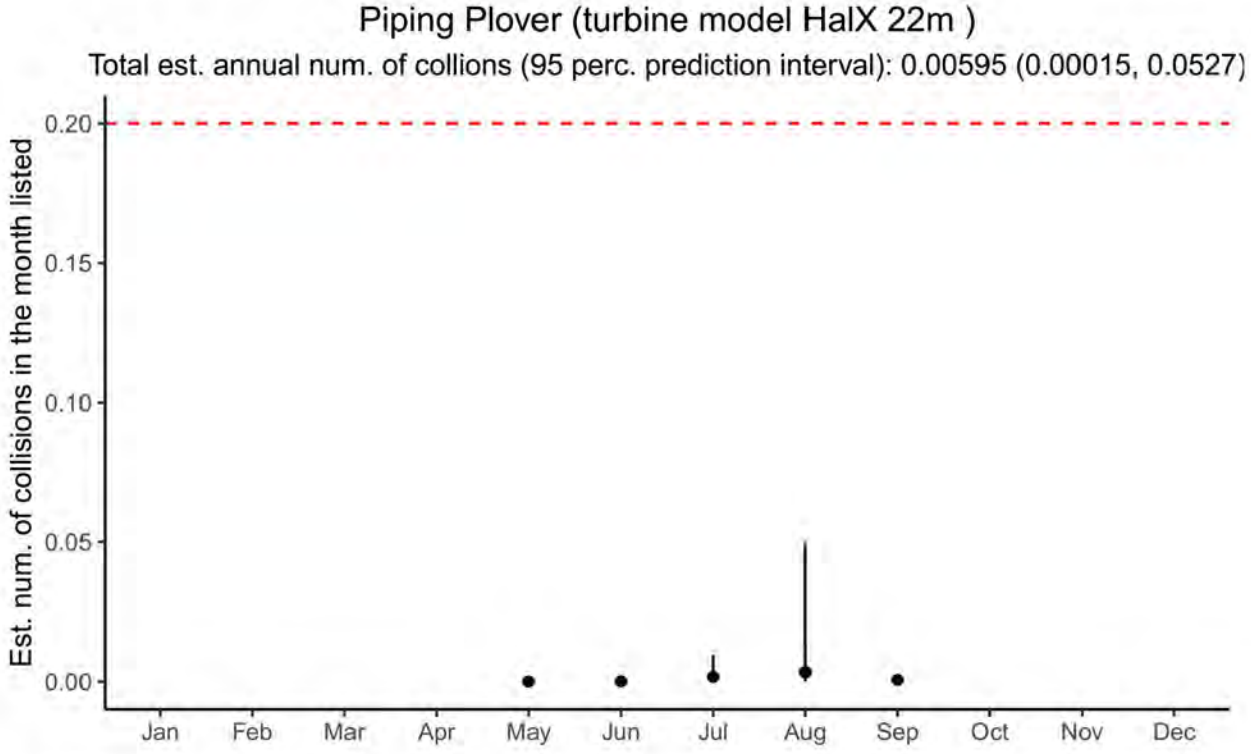

Figure 4: The predicted mean and 95 perc. prediction intervals of the number of collisions per month. Results are not shown for months that do not have movement data. Total annual collision rate and 95 perc. prediction interval are given at top. The threshold is shown divided by the number of months that movement data were available.

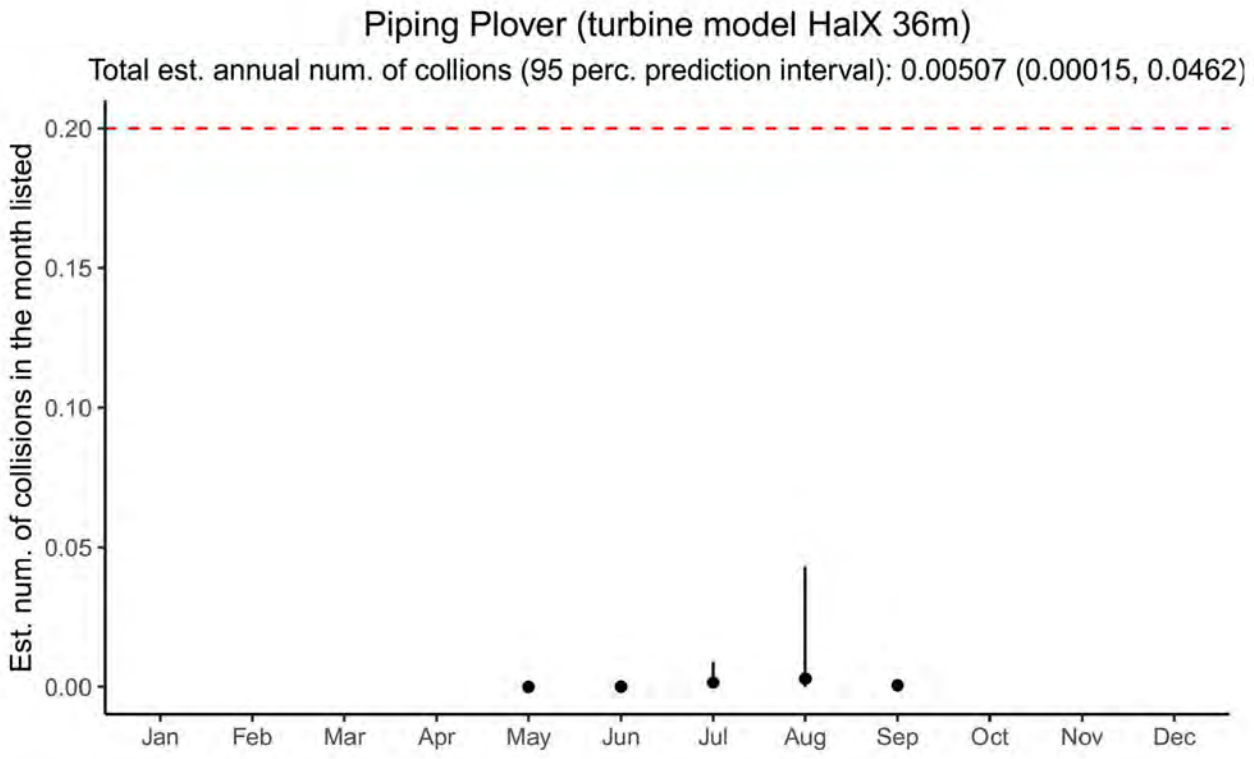

Figure 5: The predicted mean and 95 perc. prediction intervals of the number of collisions per month. Results are not shown for months that do not have movement data. Total annual collision rate and 95 perc. prediction interval are given at top. The threshold is shown divided by the number of months that movement data were available.

Summary of simulation results from SCRAM: a stochastic collision risk assessment for movement data

16 March 2023

SCRAM was developed by Biodiversity Research Institute, the University of Rhode Island, and the U.S. Fish and Wildlife Service with funding from the Bureau of Ocean Energy Management.

SCRAM run details

```
## SCRAM - the Stochastic Collision Risk Assessment for Movement version
## Version: 1.0.3 - Cathartic Adela
## Iterations: 1000
## Type of model employed: trunc
## Model option: Option 3: slower but more precise assessment
## Proportion transient in model cell: 0.335
## Project: Ocean Wind 1
## Modeler: David Bigger
## The model run was started at: Thu Mar 16 14:55:02 2023 EDT
## The model run was completed at: Thu Mar 16 15:40:21 2023 EDT
## Run 1: the probability of exceeding specified threshold (1) is < 0.001.
## Run 2: the probability of exceeding specified threshold (1) is < 0.001.
```

Model inputs used for this analysis

Table 1: Species input parameters (mean and 95 perc. range).

Species	Turbine model	Avoidance	Wing span	Body length	Speed	Upwind Prop.
Red Knot	HalX 22m	0.93 (0.92, 0.939)	0.494 (0.452, 0.534)	0.24 (0.23, 0.25)	20.158 (16.286, 23.738)	0.346 (0.346, 0.346)
Red Knot	HalX 36m	0.93 (0.92, 0.939)	0.494 (0.452, 0.534)	0.24 (0.23, 0.25)	20.158 (16.286, 23.738)	0.346 (0.346, 0.346)

Table 2: Species monthly (Jan-Jun) population estimates ± SD and assumptions/limitations as specified by the USFWS using the most recent data.

Species	Jan	Feb	Mar	Apr	May	Jun
Red Knot	10400 ± 0	10400 ± 0	10400 ± 0	10400 ± 0	59200 ± 0	59200 ± 0

Table 3: Species monthly (Jul-Dec) population estimates ± SD and assumptions/limitations as specified by the USFWS using the most recent data.

Species	Jul	Aug	Sep	Oct	Nov	Dec
Red Knot	59200 ± 0	59200 ± 0	72520 ± 0	54720 ± 0	41400 ± 0	10400 ± 0

Population data assumptions/limitations:
1) All pass through in spring - #s consistent w/Lyons et al super-population estimate for 2020 in DE Bay: 40,444 (95 perc. credible interval: 33,627–49,966).
2) Winter population estimates represent the total # of adults and sub-adults (in general).
3) Southern and northern wintering birds could be present during July - Sept.
4) Only northern wintering birds could be present during Oct - Nov.
5) Only southeast US and Caribbean birds could be present during Dec.
6) Birds from western Gulf population are excluded from totals in Atlantic region due to lack of information on extent to which they use the Atlantic region.
7) Numbers do not include HY birds in fall.
8) Dec number coming from Lyons et al 2017. Just includes SE US Birds, not Caribbean.
9) Issues with double counting addressed because birds may be present in different areas of Atlantic region for weeks to months.

Table 4: Wind farm input parameters (mean and 95 perc. range).

Species	Turbine model	Num. turbines	Rotor radius	Hub height (m)	Blade width (m)	Wind speed (mps)
Red Knot	HalX 22m	98	107 (107, 107)	129 (129, 129)	5.77 (5.77, 5.77)	7.89 (7.08, 8.78)
Red Knot	HalX 36m	98	107 (107, 107)	143 (143, 143)	5.77 (5.77, 5.77)	7.91 (7.03, 8.72)

Table 5: Wind farm input parameters (mean and 95 perc. range).

Species	Turbine model	Rotor speed (rpm)	Pitch (radians)	Farm width (km)	Lat.	Long.
Red Knot	HalX 22m	3.87 (3.48, 4.31)	0.06 (0.02, 0.11)	20	39.22	-74.32
Red Knot	HalX 36m	3.88 (3.45, 4.28)	0.06 (0.02, 0.1)	20	39.22	-74.32

Table 6: Monthly (Jan-Jun) wind farm operational percentage (mean and 95 perc. range) is given for each wind farm specification.

Species	Turbine model	Jan Op.	Feb Op.	Mar Op.	Apr Op.	May Op.	Jun Op.
Red Knot	HalX 36m	91.3 (88, 94.7)	92.5 (88.8, 96.1)	91.5 (87.7, 95.2)	91.8 (89.7, 94)	90.7 (87, 94.7)	89.6 (85.3, 93.6)
Red Knot	HalX 22m	91.4 (88.3, 94.4)	92.5 (88.7, 95.9)	91.5 (87.6, 95.3)	91.8 (89.8, 93.9)	90.7 (87.1, 94.5)	89.5 (85.5, 93.7)

Table 7: Monthly (Jul-Dec) wind farm operational percentage (mean and 95 perc. range) is given for each wind farm specification.

Species	Turbine model	Jul Op.	Aug Op.	Sep Op.	Oct Op.	Nov Op.	Dec Op.
Red Knot	HalX 36m	87.6 (83.4, 91.8)	86.1 (79.8, 92.3)	87.6 (81.7, 93.2)	89.9 (86, 93.9)	90.3 (86, 94.8)	91.4 (88.2, 94.6)
Red Knot	HalX 22m	87.5 (83.2, 91.9)	86.2 (79.7, 92.4)	87.7 (82.3, 93)	90 (86.2, 94.3)	90.2 (85.8, 94.6)	91.4 (88, 94.7)

Results for the SCRAM simulation

Table 8: The populations estimate for each month and the estimated daily number of (95 perc. prediction intervals) animals in the model cell and collisions at the wind farm. Results are not shown for months that do not have movement data. This does not mean that collisions could not occur in those months, but we do not have movement data to estimate collisions during these periods.

Species	Turbine model	Month	Population estimate	Est. daily num. of animals in the model cell	Est. daily num. of collisions in the wind farm
Red Knot	HalX 22m	Jan	10400		
Red Knot	HalX 22m	Feb	10400		
Red Knot	HalX 22m	Mar	10400		
Red Knot	HalX 22m	Apr	10400		
Red Knot	HalX 22m	May	59200		
Red Knot	HalX 22m	Jun	59200		
Red Knot	HalX 22m	Jul	59200		
Red Knot	HalX 22m	Aug	59200	0.6557 (0, 8.406)	0.000217 (0, 0.00296)
Red Knot	HalX 22m	Sep	72520	1.321 (0, 26.96)	0.000447 (0, 0.00918)
Red Knot	HalX 22m	Oct	54720	0 (0, 0)	0 (0, 0)
Red Knot	HalX 22m	Nov	41400	5.281 (0, 18.47)	0.00183 (0, 0.00753)
Red Knot	HalX 22m	Dec	10400		
Red Knot	HalX 36m	Jan	10400		
Red Knot	HalX 36m	Feb	10400		
Red Knot	HalX 36m	Mar	10400		
Red Knot	HalX 36m	Apr	10400		
Red Knot	HalX 36m	May	59200		
Red Knot	HalX 36m	Jun	59200		
Red Knot	HalX 36m	Jul	59200		
Red Knot	HalX 36m	Aug	59200	0.6557 (0, 8.406)	0.000304 (0, 0.0041)
Red Knot	HalX 36m	Sep	72520	1.321 (0, 26.96)	0.000637 (0, 0.013)
Red Knot	HalX 36m	Oct	54720	0 (0, 0)	0 (0, 0)
Red Knot	HalX 36m	Nov	41400	5.281 (0, 18.47)	0.00259 (0, 0.0104)
Red Knot	HalX 36m	Dec	10400		

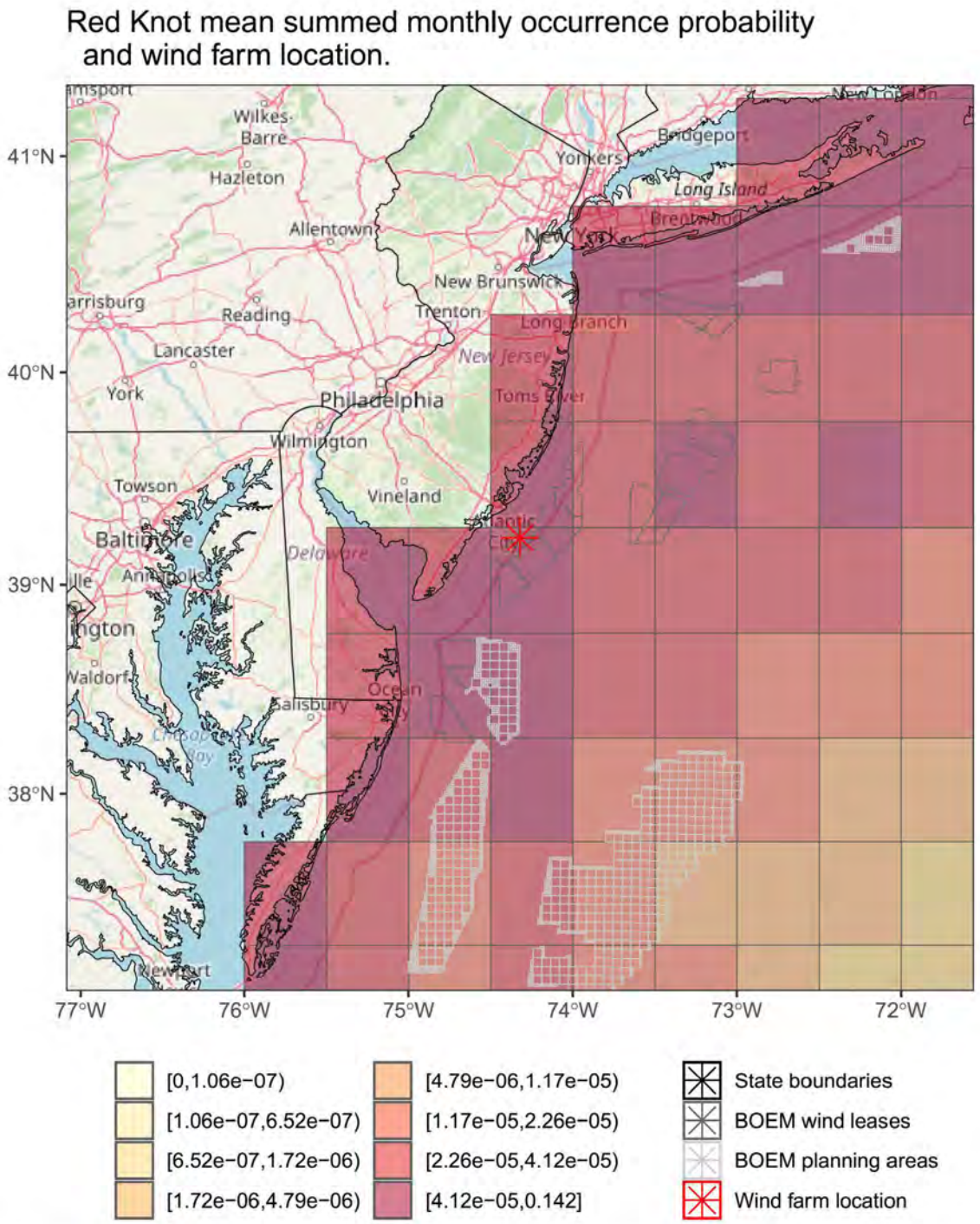

Figure 1: A map of the mean monthly species occurrence probabities (i.e., the mean of all summed daily occurrence probabilities across all months) and wind farm location. Collision estimates use summed daily occurrence probability rather than these values as shown; the values in this figure are presented for display purposes only to show relative differences in occurrence across the area of interest.

Table 9: The estimated monthly number (95 perc. prediction intervals) of collisions. Results are not shown for months that do not have movement data and does not mean that collisions could not occur in those months.

Species	Turbine model	month	Est. num. of collisions
Red Knot	HalX 22m	Jan	
Red Knot	HalX 22m	Feb	
Red Knot	HalX 22m	Mar	
Red Knot	HalX 22m	Apr	
Red Knot	HalX 22m	May	
Red Knot	HalX 22m	Jun	
Red Knot	HalX 22m	Jul	
Red Knot	HalX 22m	Aug	0.00674 (0, 0.0917)
Red Knot	HalX 22m	Sep	0.0134 (0, 0.276)
Red Knot	HalX 22m	Oct	1.91e-05 (0, 3e-05)
Red Knot	HalX 22m	Nov	0.0549 (0, 0.226)
Red Knot	HalX 22m	Dec	
Red Knot	HalX 36m	Jan	
Red Knot	HalX 36m	Feb	
Red Knot	HalX 36m	Mar	
Red Knot	HalX 36m	Apr	
Red Knot	HalX 36m	May	
Red Knot	HalX 36m	Jun	
Red Knot	HalX 36m	Jul	
Red Knot	HalX 36m	Aug	0.00946 (0, 0.127)
Red Knot	HalX 36m	Sep	0.0191 (0, 0.39)
Red Knot	HalX 36m	Oct	1.91e-05 (0, 3e-05)
Red Knot	HalX 36m	Nov	0.0778 (0, 0.312)
Red Knot	HalX 36m	Dec	
Red Knot	HalX 22m	Annual	0.0751 (0.00012, 0.36)
Red Knot	HalX 36m	Annual	0.106 (0.00012, 0.525)

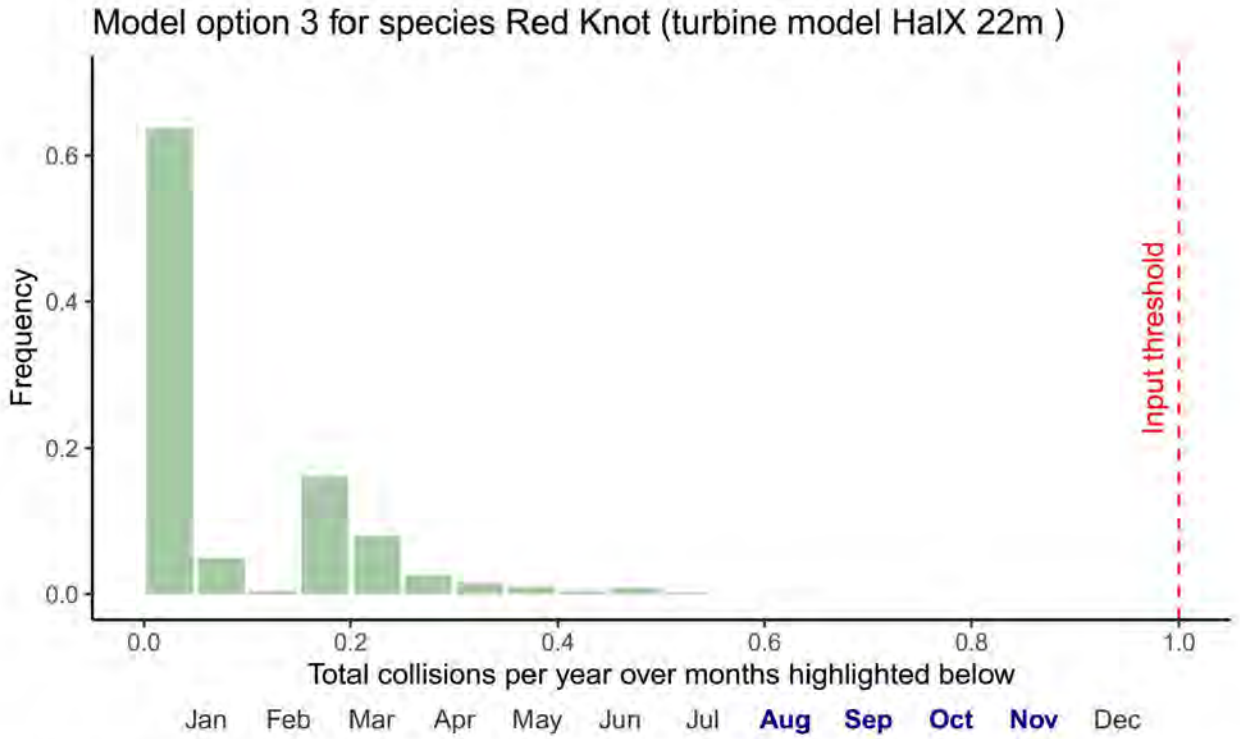

Figure 2: A frequency histogram of the total number of collisions per year. The heights of the bars show the relative frequency of each value. Months for which movement data were provided or available are shown in bold; only bold months are shown in histogram of annual collisions.

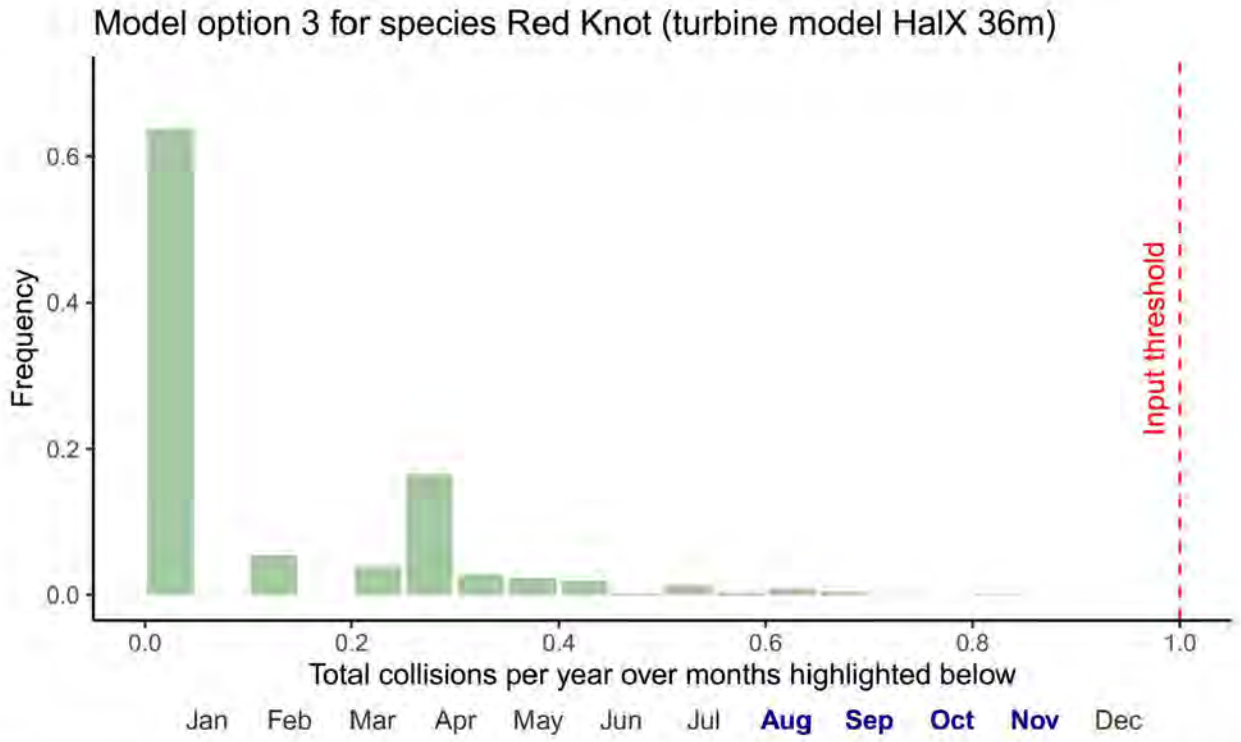

Figure 3: A frequency histogram of the total number of collisions per year. The heights of the bars show the relative frequency of each value. Months for which movement data were provided or available are shown in bold: only bold months are shown in histogram of annual collisions.

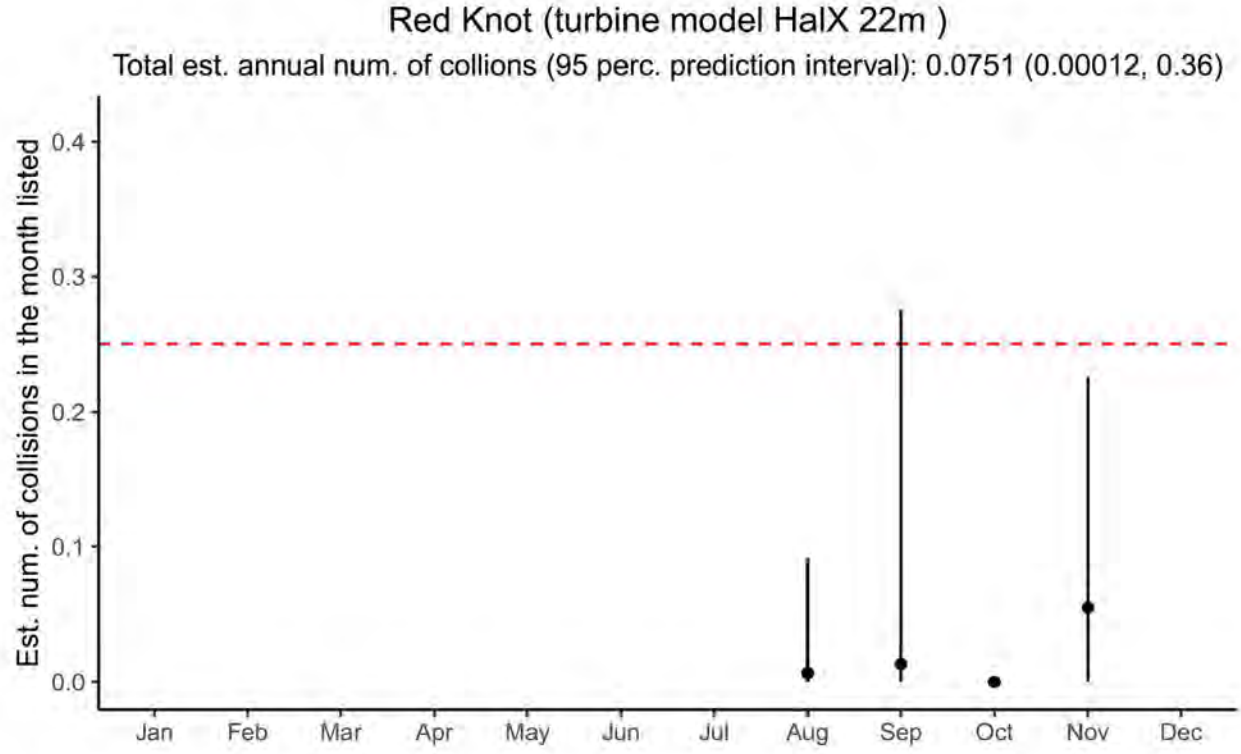

Figure 4: The predicted mean and 95 perc. prediction intervals of the number of collisions per month. Results are not shown for months that do not have movement data. Total annual collision rate and 95 perc. prediction interval are given at top. The threshold is shown divided by the number of months that movement data were available.

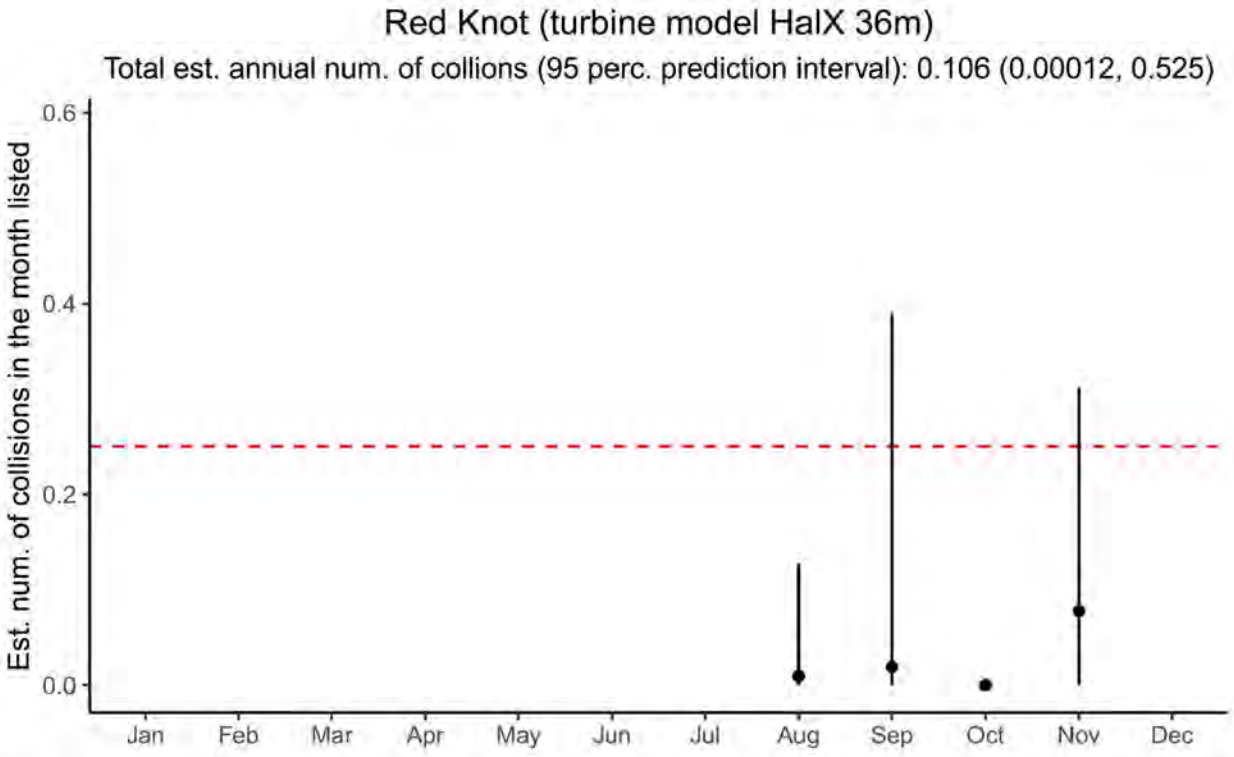

Figure 5: The predicted mean and 95 perc. prediction intervals of the number of collisions per month. Results are not shown for months that do not have movement data. Total annual collision rate and 95 perc. prediction interval are given at top. The threshold is shown divided by the number of months that movement data were available.

Summary of simulation results from SCRAM: a stochastic collision risk assessment for movement data

16 March 2023

SCRAM was developed by Biodiversity Research Institute, the University of Rhode Island, and the U.S. Fish and Wildlife Service with funding from the Bureau of Ocean Energy Management.

SCRAM run details

```
## SCRAM - the Stochastic Collision Risk Assessment for Movement version
## Version: 1.0.3 - Cathartic Adela
## Iterations: 1000
## Type of model employed: trunc
## Model option: Option 3: slower but more precise assessment
## Proportion transient in model cell: NA
## Project: Ocean Wind 1
## Modeler: David Bigger
## The model run was started at: Thu Mar 16 16:10:09 2023 EDT
## The model run was completed at: Thu Mar 16 16:55:02 2023 EDT
## Run 1: the probability of exceeding specified threshold (1) is < 0.001.
## Run 2: the probability of exceeding specified threshold (1) is < 0.001.
```

Model inputs used for this analysis

Table 1: Species input parameters (mean and 95 perc. range).

Species	Turbine model	Avoidance	Wing span	Body length	Speed	Upwind Prop.
Roseate Tern	HalX 22m	0.93 (0.92, 0.938)	0.76 (0.723, 0.799)	0.371 (0.33, 0.409)	12.887 (4.056, 23.039)	0.375 (0.375, 0.375)
Roseate Tern	HalX 36m	0.93 (0.92, 0.938)	0.76 (0.723, 0.799)	0.371 (0.33, 0.409)	12.887 (4.056, 23.039)	0.375 (0.375, 0.375)

Table 2: Species monthly (Jan-Jun) population estimates ± SD and assumptions/limitations as specified by the USFWS using the most recent data.

Species	Jan	Feb	Mar	Apr	May	Jun
Roseate Tern	0 ± 0	0 ± 0	0 ± 0	10916 ± 0	10916 ± 0	10916 ± 0

Table 3: Species monthly (Jul-Dec) population estimates ± SD and assumptions/limitations as specified by the USFWS using the most recent data.

Species	Jul	Aug	Sep	Oct	Nov	Dec
Roseate Tern	16251 ± 0	16251 ± 0	16251 ± 0	16251 ± 0	0 ± 0	0 ± 0

Population data assumptions/limitations:
1) Entire NW Atlantic pop could be present in area during months listed.
2) Average of most recent (2018 and 2019) productivity data from three largest colonies (representing >90 perc. of population) representative of entire population.
3) Fledging and post-breeding dispersal period occurs from July through Sept.
4) Numbers of non-breeding adults are not included.
5) Does not include non-breeding 1 and 2 year old birds that return but do not breed.
6) From Gochfeld and Burger (2020): Northeastern birds first arrive at Nantucket and Martha's Vineyard, MA, in large flocks, then disperse north as well as west. They arrive 26 Apr-20 May at Bird I., MA (Nisbet 1980, Nisbet 1981b, Nisbet 1989b), slightly later at Falkner I., CT, and Great Gull I., NY.
7) From Gochfeld and Burger (2020): Apparently all birds migrate directly from the staging area around Cape Cod across the w. North Atlantic to the West Indies (Nisbet 1984, C. Mostello). Very small numbers occur at sea off N. Carolina from late Aug to late Sep, with a peak in early Sep; the latest date was 28 Oct (D. Lee).

Table 4: Wind farm input parameters (mean and 95 perc. range).

Species	Turbine model	Num. turbines	Rotor radius	Hub height (m)	Blade width (m)	Wind speed (mps)
Roseate Tern	HalX 22m	98	107 (107, 107)	129 (129, 129)	5.77 (5.77, 5.77)	7.89 (7.07, 8.73)
Roseate Tern	HalX 36m	98	107 (107, 107)	143 (143, 143)	5.77 (5.77, 5.77)	7.9 (7.02, 8.73)

Table 5: Wind farm input parameters (mean and 95 perc. range).

Species	Turbine model	Rotor speed (rpm)	Pitch (radians)	Farm width (km)	Lat.	Long.
Roseate Tern	HalX 22m	3.87 (3.47, 4.28)	0.06 (0.02, 0.1)	20	39.22	-74.32
Roseate Tern	HalX 36m	3.88 (3.45, 4.29)	0.06 (0.02, 0.11)	20	39.22	-74.32

Table 6: Monthly (Jan-Jun) wind farm operational percentage (mean and 95 perc. range) is given for each wind farm specification.

Species	Turbine model	Jan Op.	Feb Op.	Mar Op.	Apr Op.	May Op.	Jun Op.
Roseate Tern	HalX 36m	91.4 (88, 94.4)	92.6 (89, 96.2)	91.5 (87.6, 95.1)	91.8 (89.9, 93.9)	90.7 (86.7, 94.3)	89.6 (85.7, 93.5)
Roseate Tern	HalX 22m	91.4 (88.3, 94.8)	92.6 (89.1, 96.3)	91.5 (87.5, 95.3)	91.8 (89.7, 93.8)	90.7 (87, 94.6)	89.6 (85.7, 93.7)

Table 7: Monthly (Jul-Dec) wind farm operational percentage (mean and 95 perc. range) is given for each wind farm specification.

Species	Turbine model	Jul Op.	Aug Op.	Sep Op.	Oct Op.	Nov Op.	Dec Op.
Roseate Tern	HalX 36m	87.7 (83.4, 91.9)	86 (79.4, 92.3)	87.6 (82.2, 92.9)	90.1 (85.9, 94.3)	90.2 (85.6, 94.7)	91.3 (87.9, 94.4)
Roseate Tern	HalX 22m	87.8 (83.6, 92.3)	85.9 (79.8, 92.2)	87.7 (82.2, 93)	90 (85.6, 94.6)	90.3 (86, 94.6)	91.4 (88.2, 94.7)

Results for the SCRAM simulation

Table 8: The populations estimate for each month and the estimated daily number of (95 perc. prediction intervals) animals in the model cell and collisions at the wind farm. Results are not shown for months that do not have movement data. This does not mean that collisions could not occur in those months, but we do not have movement data to estimate collisions during these periods.

Species	Turbine model	Month	Population estimate	Est. daily num. of animals in the model cell	Est. daily num. of collisions in the wind farm
Roseate Tern	HalX 22m	Jan	0		
Roseate Tern	HalX 22m	Feb	0		
Roseate Tern	HalX 22m	Mar	0		
Roseate Tern	HalX 22m	Apr	10916		
Roseate Tern	HalX 22m	May	10916		
Roseate Tern	HalX 22m	Jun	10916		
Roseate Tern	HalX 22m	Jul	16251		
Roseate Tern	HalX 22m	Aug	16251		
Roseate Tern	HalX 22m	Sep	16251		
Roseate Tern	HalX 22m	Oct	16251		
Roseate Tern	HalX 22m	Nov	0		
Roseate Tern	HalX 22m	Dec	0		
Roseate Tern	HalX 36m	Jan	0		
Roseate Tern	HalX 36m	Feb	0		
Roseate Tern	HalX 36m	Mar	0		
Roseate Tern	HalX 36m	Apr	10916		
Roseate Tern	HalX 36m	May	10916		
Roseate Tern	HalX 36m	Jun	10916		
Roseate Tern	HalX 36m	Jul	16251		
Roseate Tern	HalX 36m	Aug	16251		
Roseate Tern	HalX 36m	Sep	16251		
Roseate Tern	HalX 36m	Oct	16251		
Roseate Tern	HalX 36m	Nov	0		
Roseate Tern	HalX 36m	Dec	0		

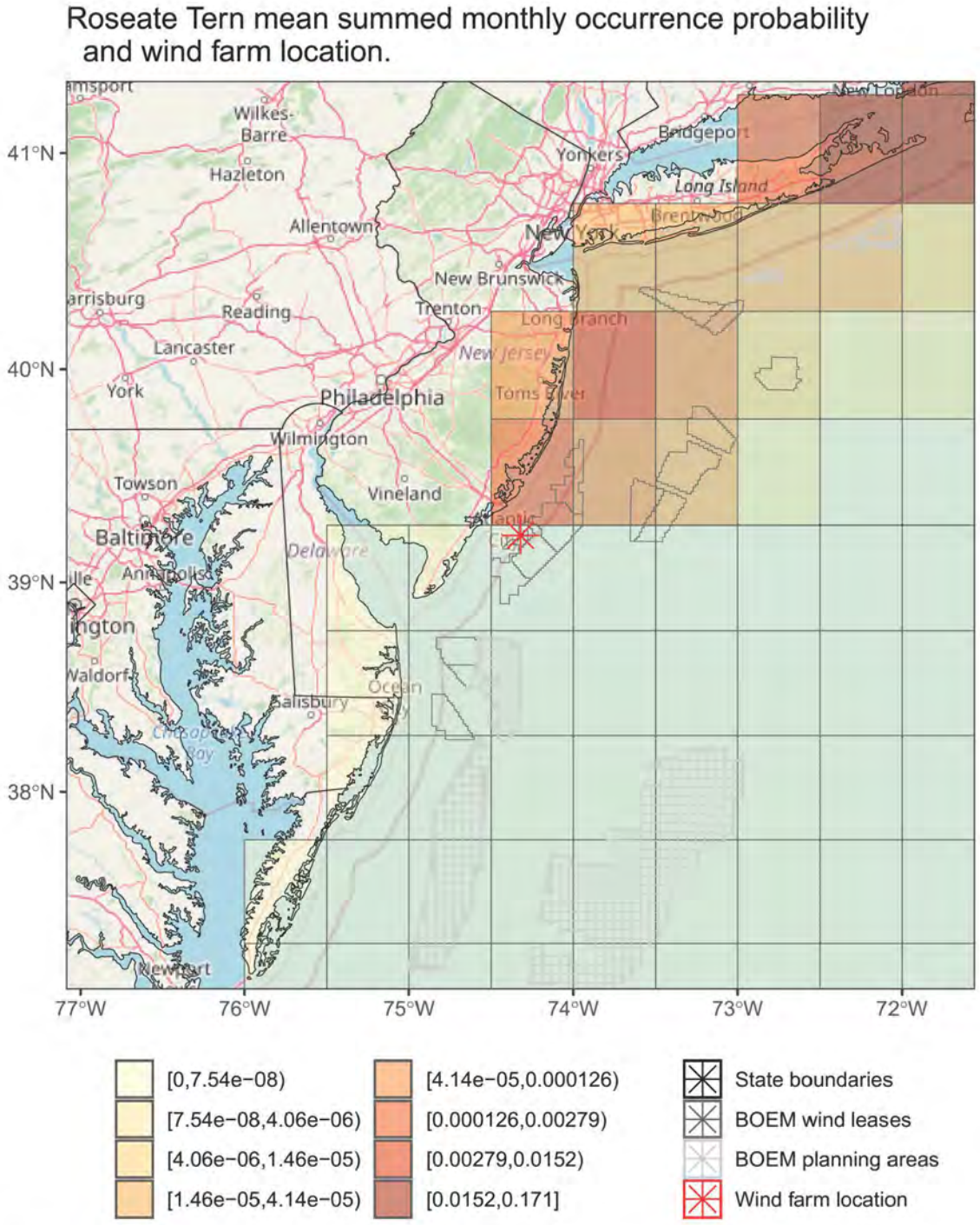

Figure 1: A map of the mean monthly species occurrence probabities (i.e., the mean of all summed daily occurrence probabilities across all months) and wind farm location. Collision estimates use summed daily occurrence probability rather than these values as shown; the values in this figure are presented for display purposes only to show relative differences in occurrence across the area of interest.

Table 9: The estimated monthly number (95 perc. prediction intervals) of collisions. Results are not shown for months that do not have movement data and does not mean that collisions could not occur in those months.

Species	Turbine model	month	Est. num. of collisions
Roseate Tern	HalX 22m	Jan	
Roseate Tern	HalX 22m	Feb	
Roseate Tern	HalX 22m	Mar	
Roseate Tern	HalX 22m	Apr	
Roseate Tern	HalX 22m	May	
Roseate Tern	HalX 22m	Jun	
Roseate Tern	HalX 22m	Jul	
Roseate Tern	HalX 22m	Aug	
Roseate Tern	HalX 22m	Sep	
Roseate Tern	HalX 22m	Oct	
Roseate Tern	HalX 22m	Nov	
Roseate Tern	HalX 22m	Dec	
Roseate Tern	HalX 36m	Jan	
Roseate Tern	HalX 36m	Feb	
Roseate Tern	HalX 36m	Mar	
Roseate Tern	HalX 36m	Apr	
Roseate Tern	HalX 36m	May	
Roseate Tern	HalX 36m	Jun	
Roseate Tern	HalX 36m	Jul	
Roseate Tern	HalX 36m	Aug	
Roseate Tern	HalX 36m	Sep	
Roseate Tern	HalX 36m	Oct	
Roseate Tern	HalX 36m	Nov	
Roseate Tern	HalX 36m	Dec	
Roseate Tern	HalX 22m	Annual	0 (0, 0)
Roseate Tern	HalX 36m	Annual	0 (0, 0)

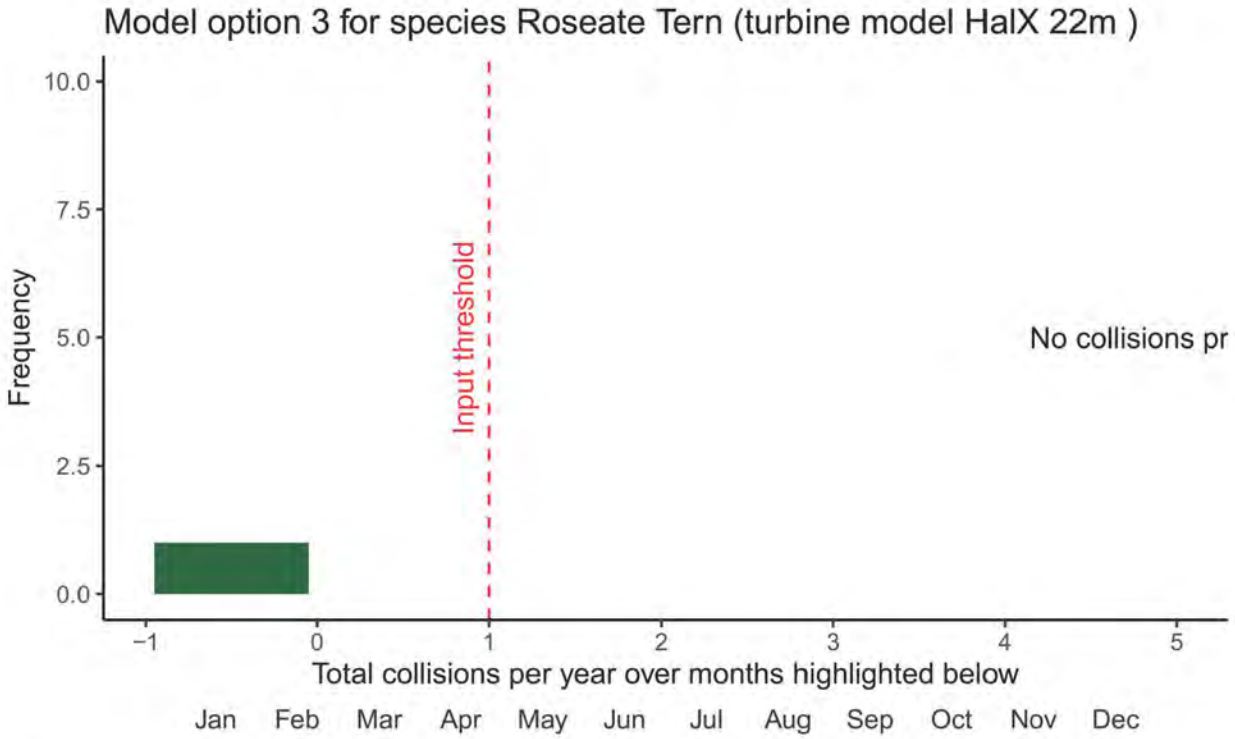

Figure 2: A frequency histogram of the total number of collisions per year. The heights of the bars show the relative frequency of each value. Months for which movement data were provided or available are shown in bold; only bold months are shown in histogram of annual collisions.

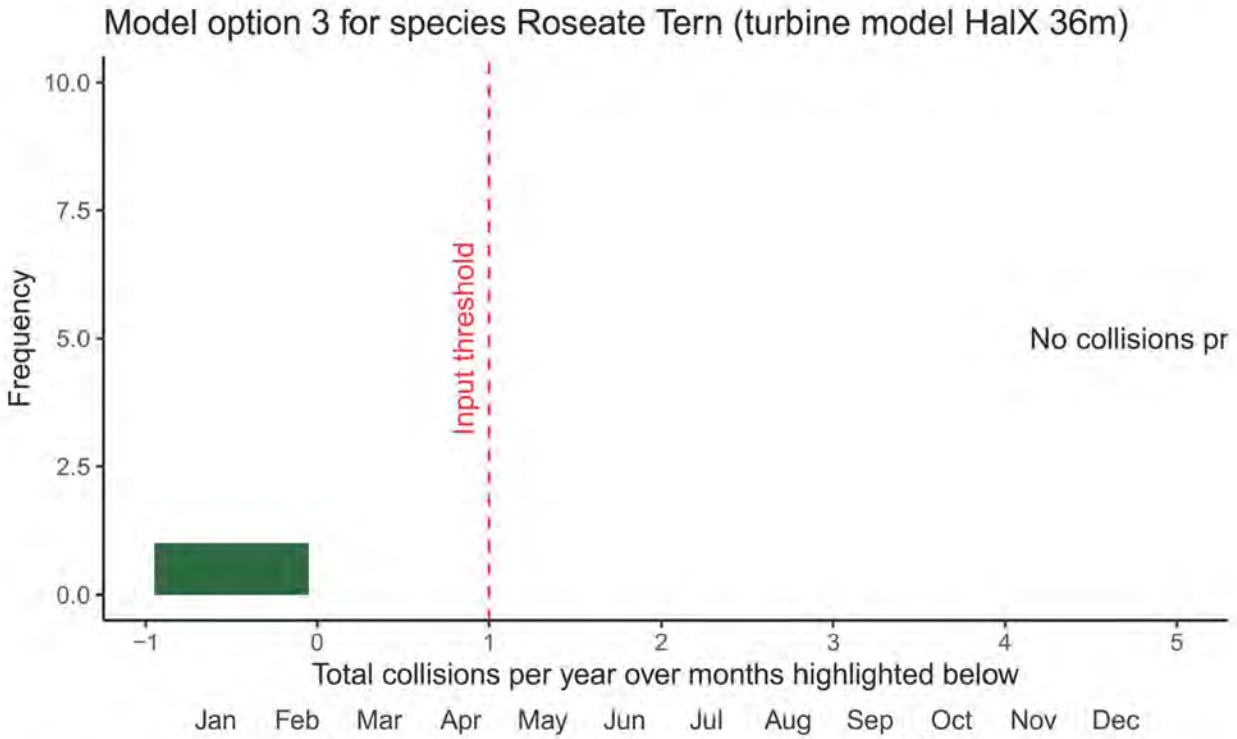

Figure 3: A frequency histogram of the total number of collisions per year. The heights of the bars show the relative frequency of each value. Months for which movement data were provided or available are shown in bold; only bold months are shown in histogram of annual collisions.

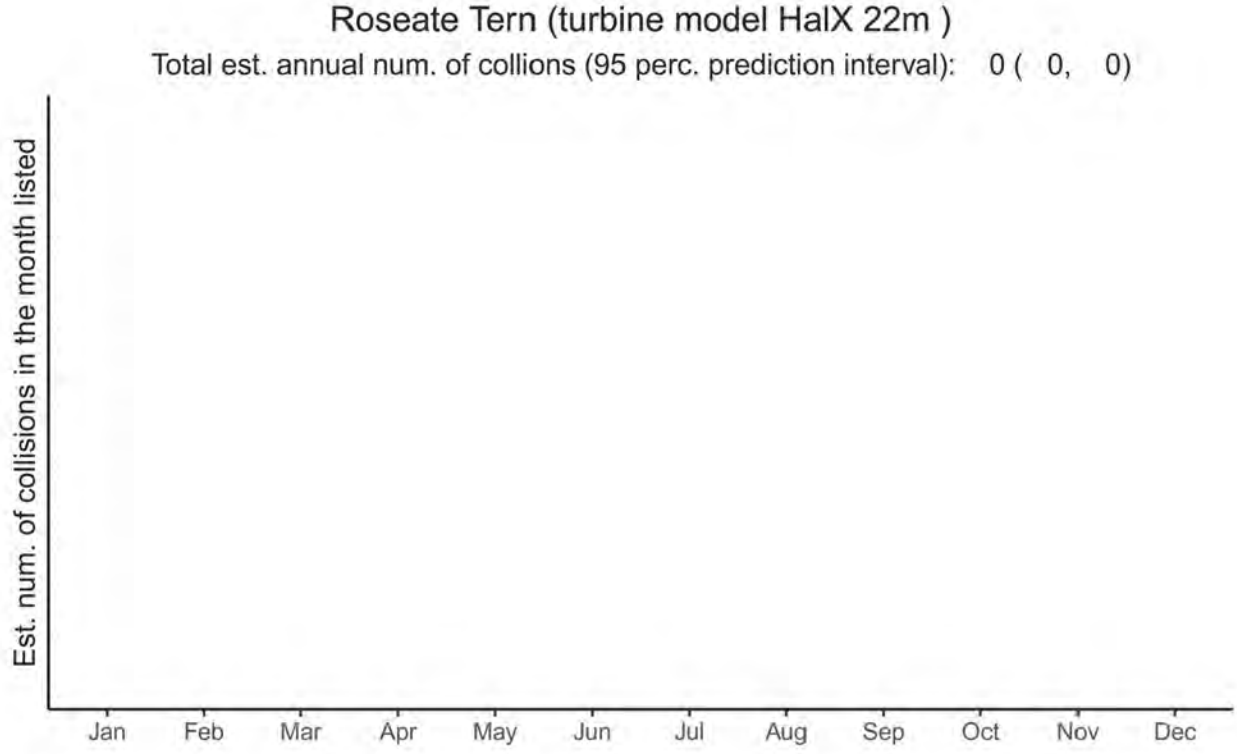

Figure 4: The predicted mean and 95 perc. prediction intervals of the number of collisions per month. Results are not shown for months that do not have movement data. Total annual collision rate and 95 perc. prediction interval are given at top. The threshold is shown divided by the number of months that movement data were available.

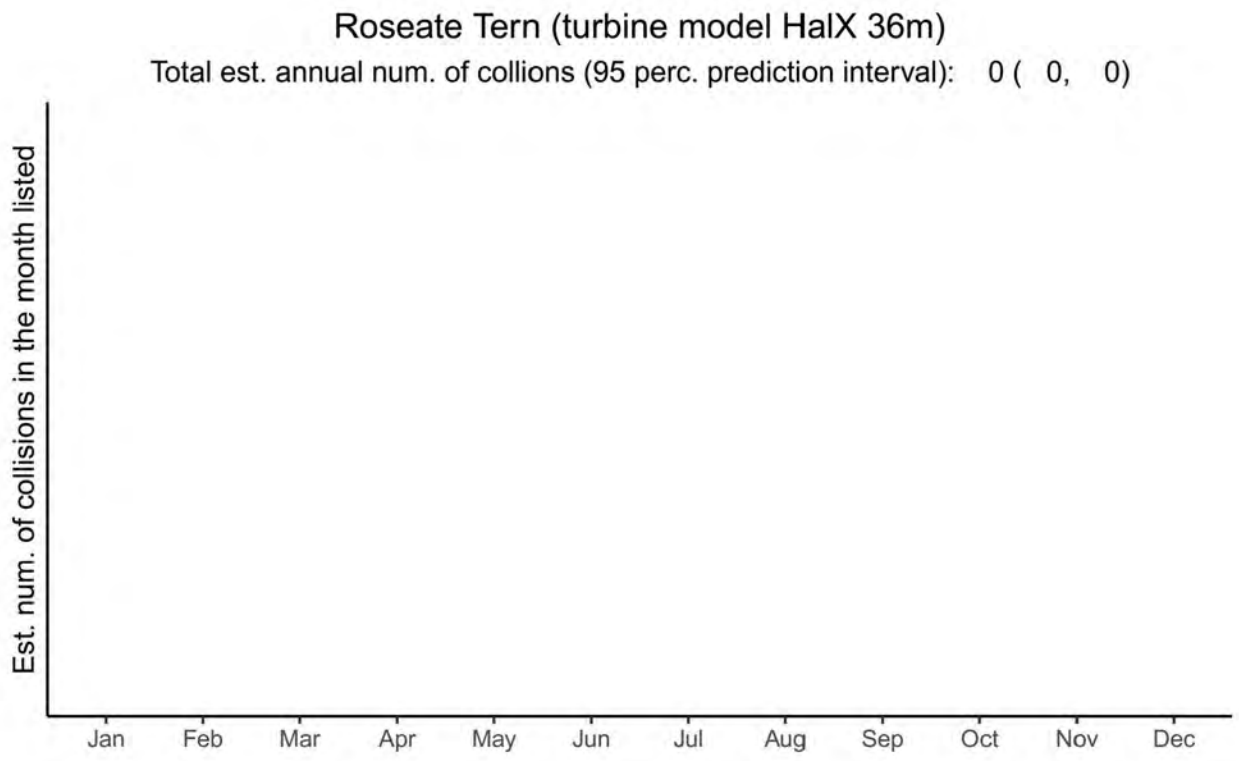

Figure 5: The predicted mean and 95 perc. prediction intervals of the number of collisions per month. Results are not shown for months that do not have movement data. Total annual collision rate and 95 perc. prediction interval are given at top. The threshold is shown divided by the number of months that movement data were available.