Revolution Wind Farm and Revolution Export Cable - Development and Operation

Addendum to the Biological Assessment

January 12, 2023

For the U.S. Fish and Wildlife Service

Project Code: 2022-002329

U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs

Pursuant to Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, on August 29, 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 Revolution Wind Farm (RWF) and Revolution Wind Export Cable (RWEC), a commercial wind energy facility. On November 17, 2022, BOEM submitted an updated Biological Assessment (BA) for this ESA consultation. USFWS responded on November 25, 2022, indicating that the consultation package was adequate and complete. This document serves as an addendum to the BA.

Since the submission of the final BA on November 17th, 2022, BOEM received some additional information from the lessee November 18th, 2022, regarding details of the project. This information was provided based on a request for additional information from the USFWS regarding operational inputs used in the collision risk models in the BA. The lessee provided an evaluation of the length of time the wind turbine generators (WTGs) would be operational based on various WTG characteristics. This information supplements the information currently available in the Construction and Operations Plan (COP) for Revolution Wind. The operational time periods of the WTGs depend on the hub height of the turbine. The lessee provided three scenarios of hub heights and cut-in/cut-out speeds:

- 5-25 m/s at hub height elevation of 115 m,
- 3-35 m/s at hub height elevation of 115 m, and
- 3-35 m/s at hub height elevation of 156 m.

Tables 1-3 provide the operational times of the WTGs for each month based on wind speed, hub height, and cut-in and cut-out speeds.

The lessee provided detailed characteristics regarding the 11 MW WTG for which the lessee has a Turbine Supply Agreement. In November 2022, the lessee also informed BOEM that 21of the total 100 WTG positions in the Project Design Envelope (PDE) have been dismissed due to engineering, cost, schedule, and constructability issues. The PDE in the COP has not been changed, but BOEM and FWS discussed the utility of using this updated information in the consultation. The additional characteristics of the 11 MW WTG are provided in Table 4.

BOEM performed model runs with the Stochastic Collision Risk Assessment for Movement (SCRAM) model for the *rufa* red knot using this updated information with a total of 79 WTGs with a nameplate capacity of 11 MW (Table 5). The model outputs indicate that the probability of *rufa* red knot take is extremely unlikely with no lethal take expected over the life of the project. This information does not impact the effect determinations in the November BA; the project may affect, but is not likely to adversely affect *rufa* red knot. The model input files and SCRAM reports are included as an appendix to this addendum.

Table 1: Revolution Wind WTG operational times for a WTG hub height of 115 m, a cut-in speed of 5 m/s, and a cut-out speed of 25 m/s.

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Avg. [%]	89.7	89.0	86.6	84.5	80.9	81.3	77.3	74.8	78.6	85.0	88.3	89.2
Std. Dev. [pp]	3.2	3.6	3.7	4.4	5.1	5.7	4.7	6.2	5.0	4.8	3.7	4.0
WS < 4 m/s [%]	5.9	6.5	8.1	9.5	12.1	11.6	14.3	15.7	13.7	9.3	6.7	5.9
4 m/s <= WS < 6.5 m/s [%]	9.4	10.7	12.5	15.8	18.7	21.8	24.4	25.6	20.4	14.6	11.2	9.8
6.5 m/s <= WS < 10 m/s [%]	20.4	23.0	24.8	28.7	33.3	36.3	36.8	36.5	33.3	28.0	22.5	21.2
WS >= 10 m/s [%]	64.3	59.9	54.5	46.0	35.9	30.3	24.5	22.2	32.6	48.1	59.6	63.1

Table 2: Revolution Wind WTG operational times for a WTG hub height of 115 m, a cut-in speed of 5 m/s, and a cut-out speed of 25 m/s.

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Avg. [%]	96.6	96.3	95.4	94.7	93.1	93.7	91.9	91.5	92.5	94.7	96.3	96.7
Std. Dev. [pp]	1.5	1.5	2.0	2.1	3.0	2.5	2.3	2.7	2.6	2.2	1.7	1.5
WS < 4 m/s [%]	5.9	6.5	8.1	9.5	12.1	11.6	14.3	15.7	13.7	9.3	6.7	5.9
4 m/s <= WS < 6.5 m/s [%]	9.4	10.7	12.5	15.8	18.7	21.8	24.4	25.6	20.4	14.6	11.2	9.8
6.5 m/s <= WS < 10 m/s [%]	20.4	23.0	24.8	28.7	33.3	36.3	36.8	36.5	33.3	28.0	22.5	21.2
WS >= 10 m/s [%]	64.3	59.9	54.5	46.0	35.9	30.3	24.5	22.2	32.6	48.1	59.6	63.1

Table 3: Revolution Wind WTG operational times for a WTG hub height of 156 m, a cut-in speed of 3 m/s, and a cut-out speed of 35 m/s.

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Avg. [%]	96.8	96.6	95.7	95.1	93.6	94.1	92.5	92.2	93.1	95.1	96.5	96.9
Std. Dev. [pp]	1.4	1.4	1.9	2.0	2.9	2.4	2.2	2.5	2.5	2.1	1.6	1.4
WS < 4 m/s [%]	5.5	6.0	7.6	8.8	11.3	10.8	13.3	14.4	12.8	8.8	6.2	5.5
4 m/s <= WS < 6.5 m/s [%]	8.8	9.9	11.7	14.8	17.4	20.1	22.7	24.2	19.1	13.5	10.5	9.1
6.5 m/s <= WS < 10 m/s [%]	19.1	21.5	23.6	27.4	32.1	35.6	36.4	36.0	32.4	27.0	21.2	19.9
WS >= 10 m/s [%]	66.6	62.6	57.1	49.0	39.2	33.5	27.5	25.3	35.7	50.7	62.2	65.5

Table 4: Characteristics of the 11 MW WTG for which the operator has a Turbine Supply Agreement.

WTG Characteristic	Minimum	Maximum
Hub height (from mean sea level)	377 feet (115 m)	512 feet (156 m)
Turbine height (from mean sea level)	646 feet (197 m)	873 feet (266 m)
Air gap (mean sea level to the bottom of the blade tip)	93.5 feet (28.5 m)	151 feet (46 m)
Base height (foundation height to top of transition piece)	82 feet (25 m)	128 feet (39 m)
Base (tower) width (at the bottom)	19.7 feet (6 m)	26 feet (8 m)
Base (tower) width (at the top)	13 feet (4 m)	21 feet (6.4 m)
Nacelle dimensions (length × width × height)	46 × 23 × 20 feet (14 × 7 × 6 m)	72 × 33 × 39 feet (22 × 10 × 12 m)
Blade length	259 feet (79 m)	351 feet (107 m)
Maximum blade width	16 feet (5 m)	26 feet (8 m)
Rotor diameter	538 feet (164 m)	722 feet (220 m)
Operation cut-in wind speed	7 to 11 miles per hour (3–5 m per second)	
Operational cut-out wind speed	55 to 80 miles per hour (25–35 m per second)	

Table 5: Model results for the red knot from the SCRAM model using 79 11 MW WTGs based on three scenarios described in Tables 1-3.

	Model Inputs	**Scenario #**	**1**	**2**	**3**
		Turbine size (MW)	11	11	11
		Number	79	79	79
		Air gap (m)	28.5	28.5	46
Model	**Metric for red knot**	**Time Period**	**Scenario 1**	**Scenario 2**	**Scenario 3**
SCRAM	Probability of lethal take	Annual	0.001	0.001	0.016
SCRAM	Probability of lethal take	35 years	0.034	0.034	0.431
SCRAM	Years until a lethal take	-	1,000	1,000	62.5
SCRAM	Annual Fatalities	1 year	NA	NA	NA
SCRAM	Fatalities project lifetime	35 years	NA	NA	NA

Appendix A: Model input files and SCRAM modeling reports

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

22 November 2022

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: 0.91.1 - Lyrical Brachycarpus
## Iterations: 1000
## Model option: Option 3: slower but more accurate assessment
## Project: Rev Wind
## Modeler: David Bigger
## The model run was started at: Tue Nov 22 10:03:38 2022 EST
## The model run was completed at: Tue Nov 22 10:48:03 2022 EST
## 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
Red Knot	one	0.93 (0.92, 0.94)	0.5 (0.45, 0.54)	0.24 (0.23, 0.25)	20.03 (16.31, 23.91)
Red Knot	two	0.93 (0.92, 0.94)	0.5 (0.45, 0.54)	0.24 (0.23, 0.25)	20.03 (16.31, 23.91)

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	one	79 (79, 79)	97 (97, 97)	125.5 (125.5, 125.5)	5.77 (5.77, 5.77)	9.52 (5.26, 13.37)
Red Knot	two	79 (79, 79)	97 (97, 97)	125.5 (125.5, 125.5)	5.77 (5.77, 5.77)	9.53 (5.58, 13.23)

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

Species	Turbine model	Prop. upwind	Rotor speed (rpm)	Pitch (radians)	Farm width (km)	Lat.	Long.
Red Knot	one	1 (1, 1)	5.16 (2.85, 7.24)	0.03 (0.03, 0.04)	38 (38, 38)	41.16	-71.12
Red Knot	two	1 (1, 1)	5.16 (3.02, 7.17)	0.03 (0.03, 0.04)	38 (38, 38)	41.16	-71.12

Table 6: Monthly wind farm operational data (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	two	90.6 (86.6, 94.5)	90.2 (86.5, 94)	89.4 (85.7, 93.1)	88.7 (84.8, 92.4)	87.3 (83.5, 91)	87.8 (84.3, 91.3)
Red Knot	one	84.1 (80.6, 87.8)	83.4 (80.1, 86.6)	81.2 (77.7, 84.7)	79.3 (76.1, 82.3)	75.8 (72.8, 78.9)	76.2 (73.1, 79.5)

Table 7: Monthly wind farm operational data (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	two	86.1 (82.5, 89.8)	85.6 (82, 89.2)	86.7 (83.2, 90.2)	88.8 (85, 92.6)	90.2 (86.5, 94)	90.6 (86.9, 94.6)
Red Knot	one	72.4 (69.3, 75.3)	70.1 (67.3, 73)	73.6 (70.5, 76.5)	79.7 (76.4, 82.9)	82.6 (79.1, 86.1)	83.6 (80.2, 87.1)

Results for the SCRAM simulation

Table 8: The predicted mean and 95 perc. prediction intervals of the number of collisions per month and the total summed monthly number of collisions and 95 perc. prediction interval. Results are not shown for months that do not have movement data.

Species	Turbine model	month	Mean number of collisions	Lower pred. interval	Upper pred. interval
Red Knot	one	Jan			
Red Knot	one	Feb			
Red Knot	one	Mar			
Red Knot	one	Apr			
Red Knot	one	May			
Red Knot	one	Jun			
Red Knot	one	Jul			
Red Knot	one	Aug	0.023	0.019	0.029
Red Knot	one	Sep	0.558	0.443	0.665
Red Knot	one	Oct	0.045	0.036	0.055
Red Knot	one	Nov	0	0	0
Red Knot	one	Dec			
Red Knot	one	annual	0.626	0.5	0.748
Red Knot	two	Jan			
Red Knot	two	Feb			
Red Knot	two	Mar			
Red Knot	two	Apr			
Red Knot	two	May			
Red Knot	two	Jun			
Red Knot	two	Jul			
Red Knot	two	Aug	0.029	0.023	0.035
Red Knot	two	Sep	0.657	0.525	0.787
Red Knot	two	Oct	0.051	0.04	0.061
Red Knot	two	Nov	0	0	0
Red Knot	two	Dec			
Red Knot	two	annual	0.736	0.589	0.883

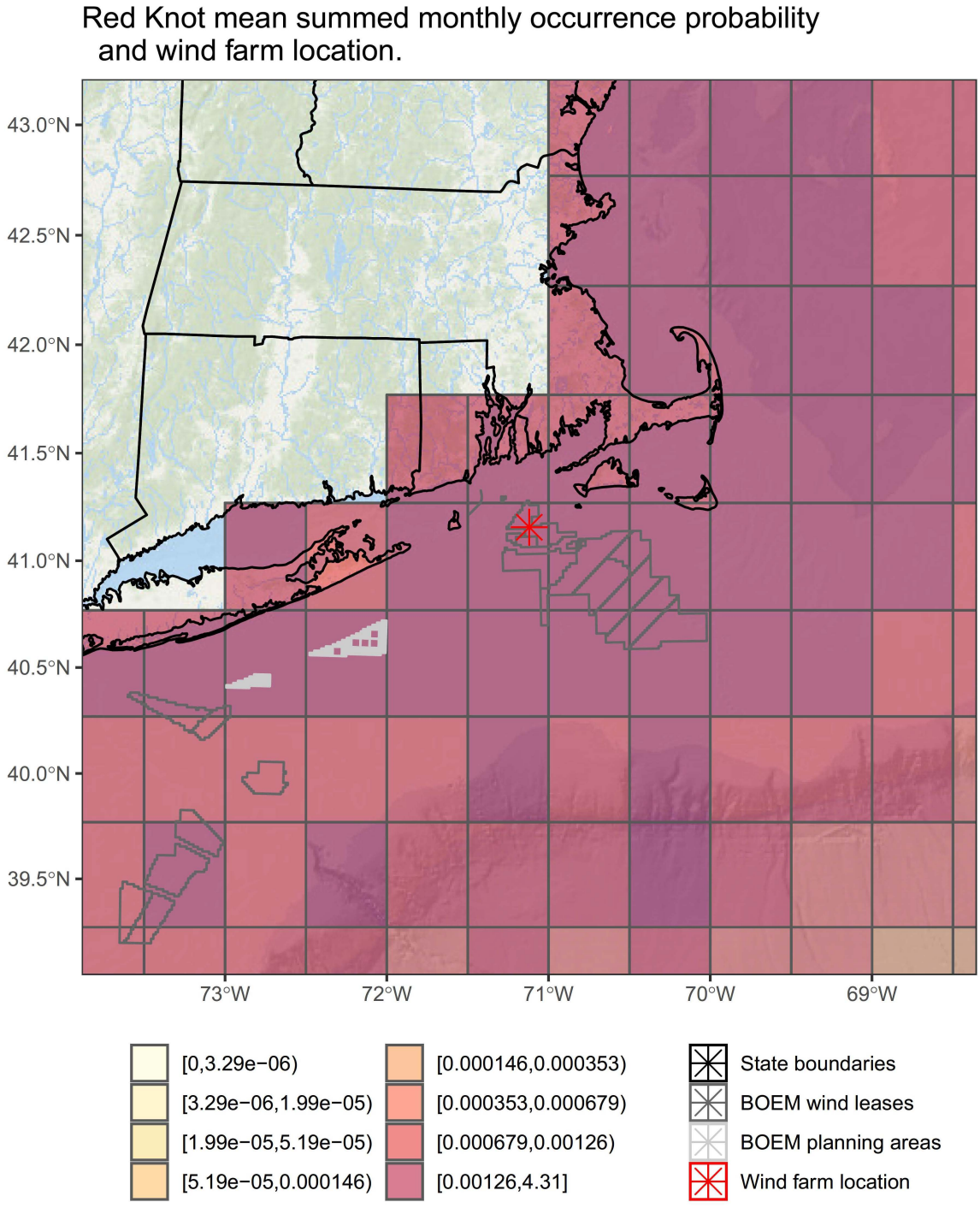


Figure 1: A map of the species occurrence probabities and wind farm location.

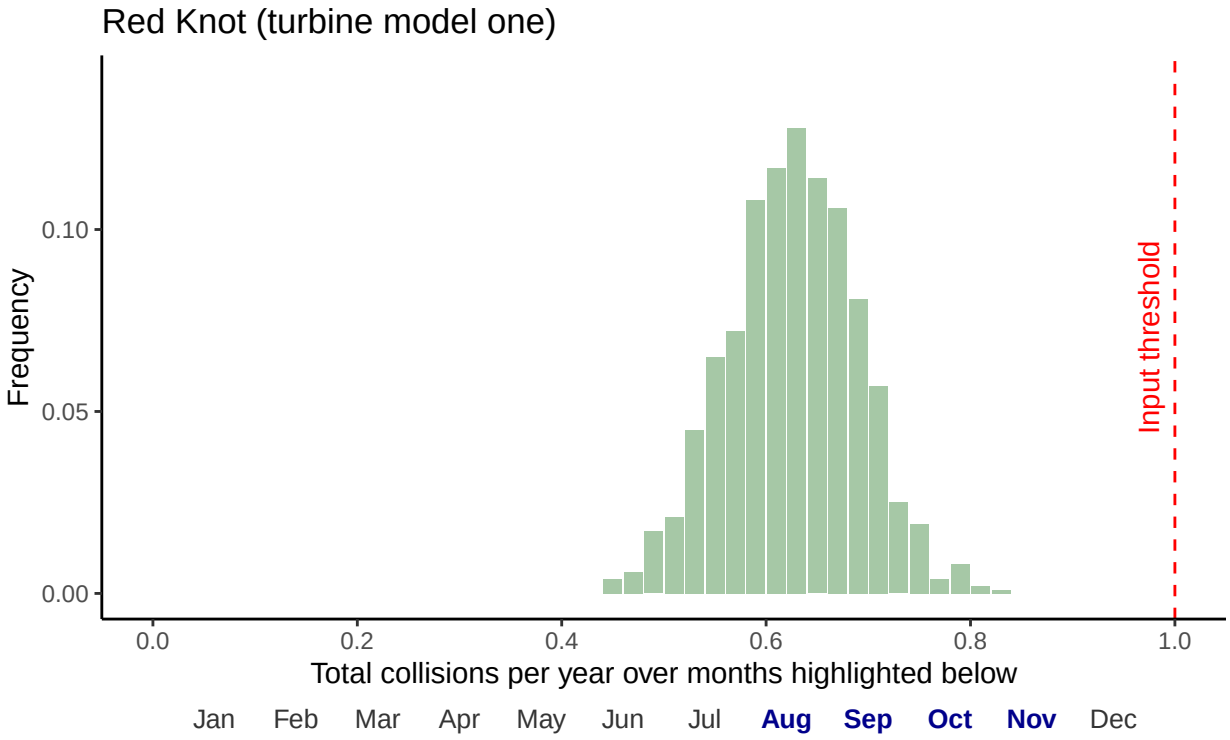
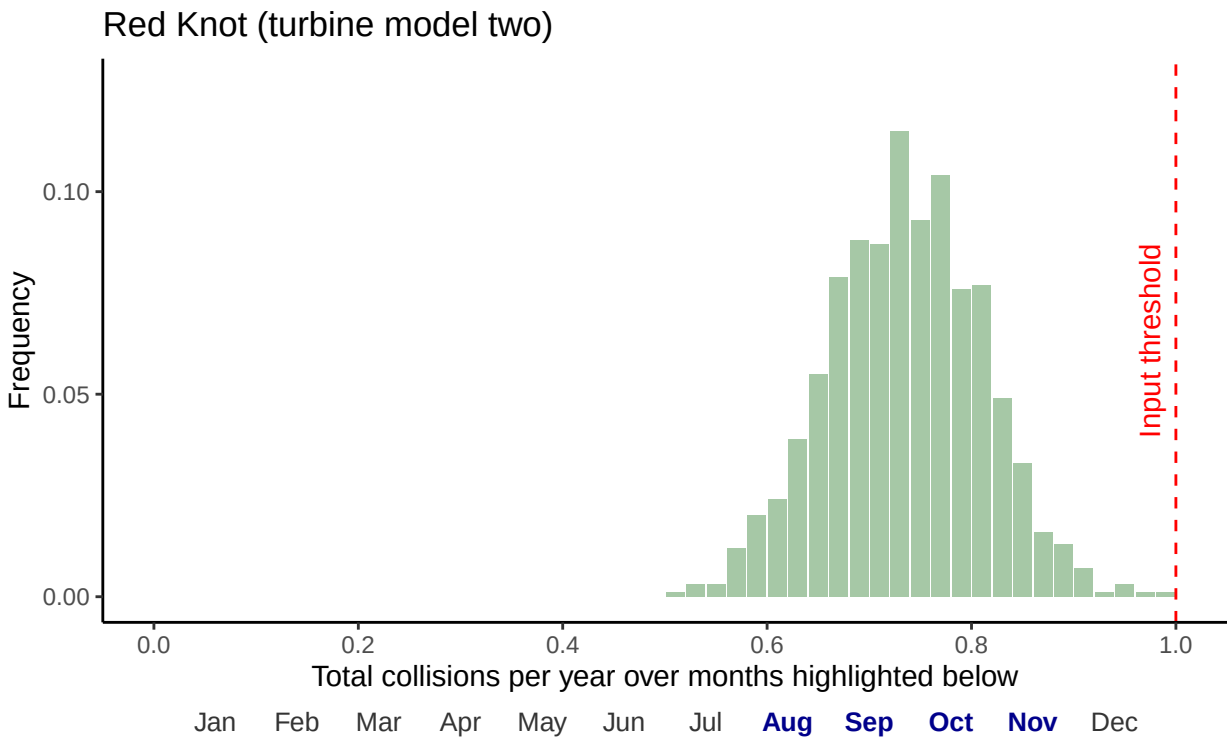


Figure 2: A frequency histogram of the total number of collisions per year. The heights of the bars show the relative frequency of each value. Months for which movement data were provided or available are shown in bold; only bold months are shown in histogram of annual collisions.



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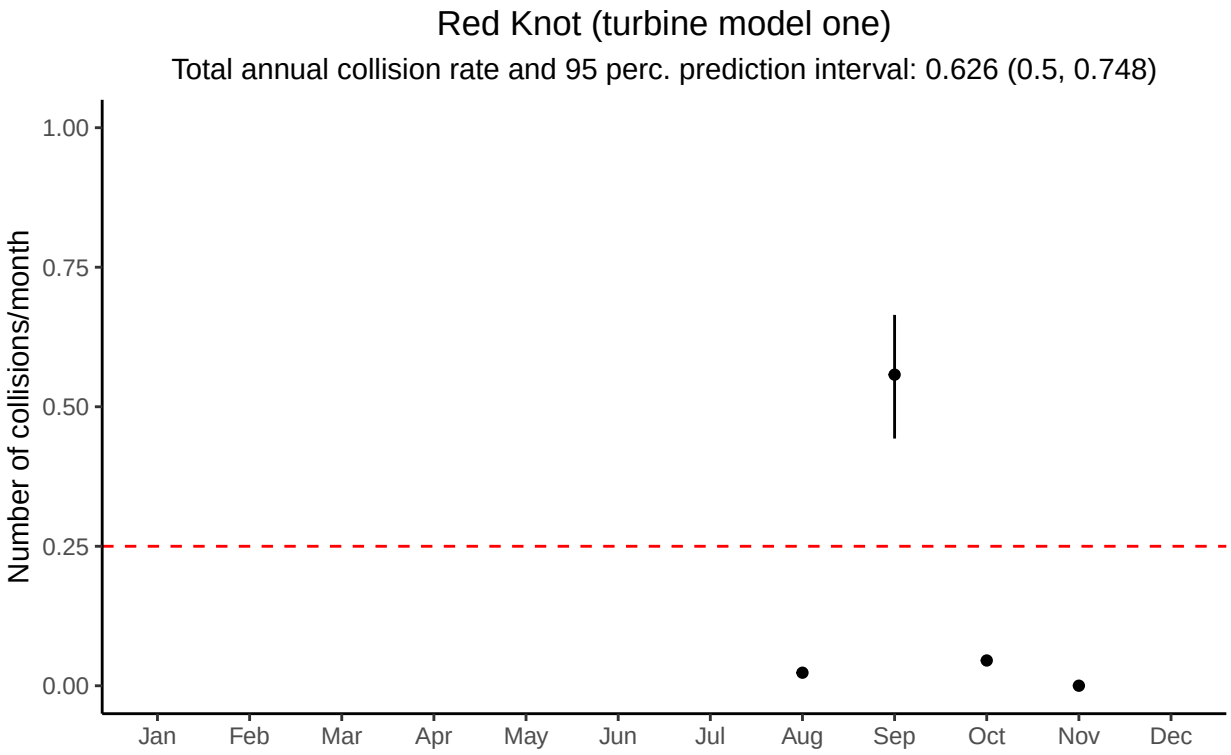
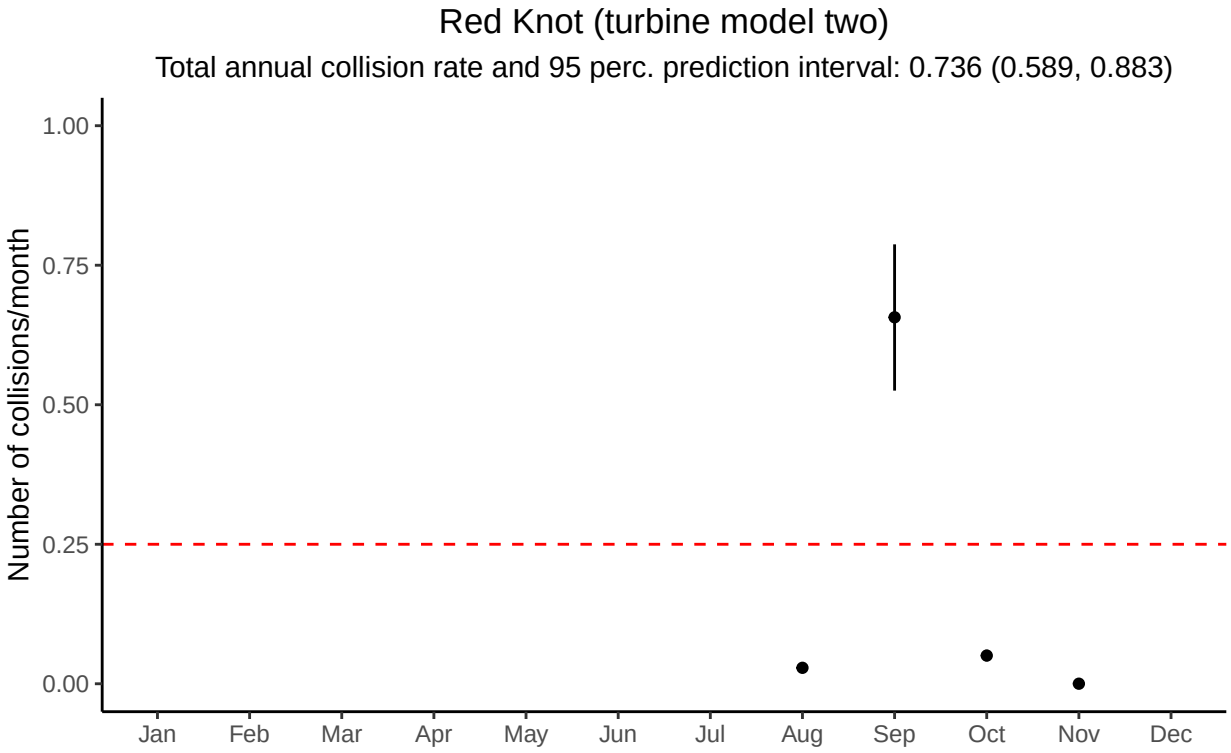


Figure 4: The predicted mean and 95 perc. prediction intervals of the number of collisions per month. Results are not shown for months that do not have movement data. Total annual collision rate and 95 perc. prediction interval are given at top. The threshold is shown divided by the number of months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



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

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## Version: 0.91.1 - Lyrical Brachycarpus
## Iterations: 1000
## Model option: Option 3: slower but more accurate assessment
## Project: Rev Wind
## Modeler: David BIgger
## The model run was started at: Mon Nov 21 14:18:38 2022 EST
## The model run was completed at: Mon Nov 21 14:40:31 2022 EST
## Run 1: the probability of exceeding specified threshold (1) is 0.016.
```

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
Red Knot	three	0.93 (0.92, 0.94)	0.49 (0.45, 0.54)	0.24 (0.23, 0.25)	20.19 (16.48, 23.78)

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).
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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	three	79 (79, 79)	97 (97, 97)	143 (143, 143)	5.77 (5.77, 5.77)	9.72 (5.72, 13.7)

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

Species	Turbine model	Prop. upwind	Rotor speed (rpm)	Pitch (radians)	Farm width (km)	Lat.	Long.
Red Knot	three	1 (1, 1)	5.26 (3.1, 7.42)	0.03 (0.03, 0.04)	38 (38, 38)	41.16	-71.12

Table 6: Monthly wind farm operational data (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	three	90.8 (87, 94.6)	90.6 (86.8, 94.2)	89.7 (86, 93.5)	89.1 (85.3, 92.8)	87.7 (84.2, 91.5)	88.2 (84.4, 91.8)

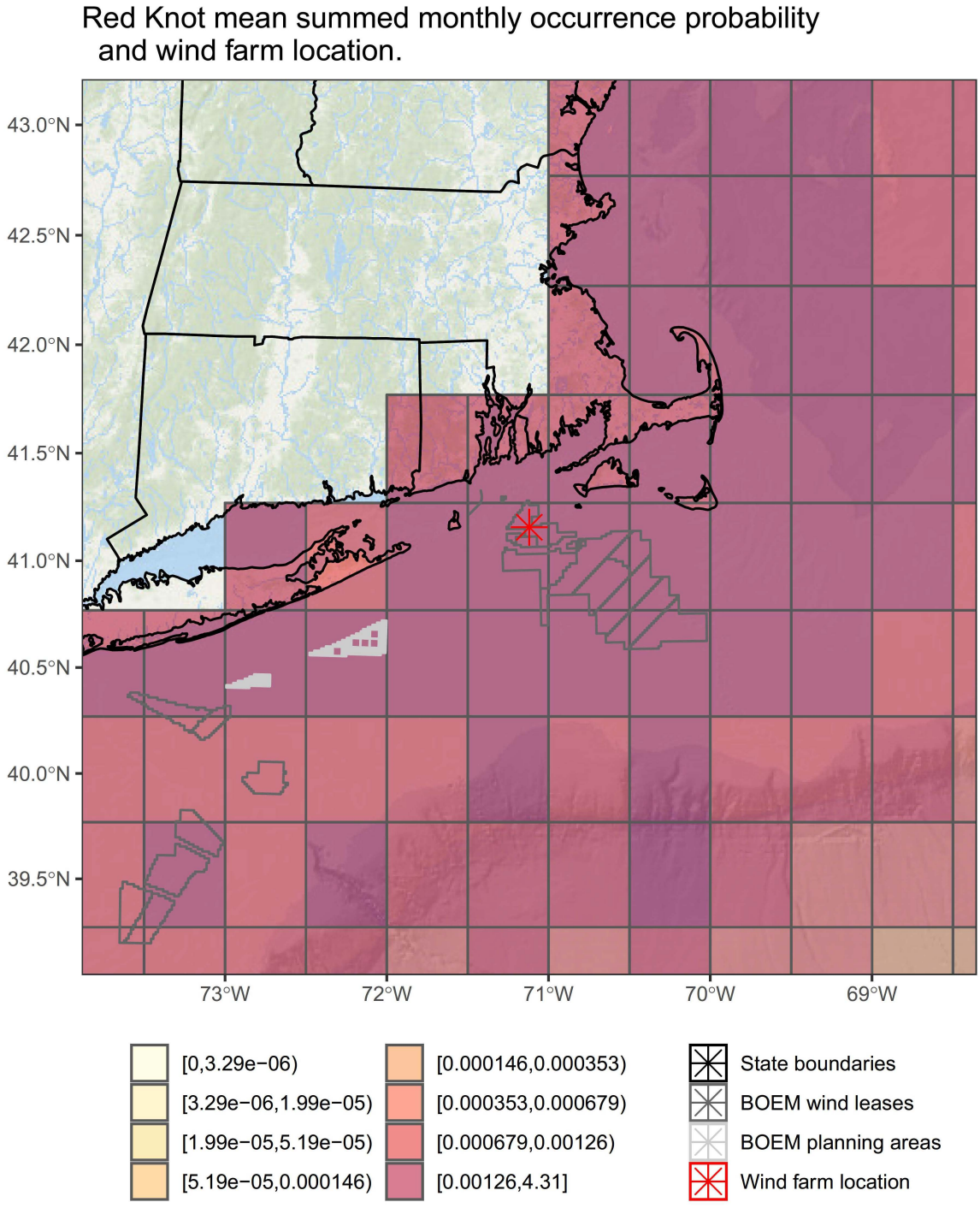
Table 7: Monthly wind farm operational data (mean and 95 perc. range) is given for each wind farm specification.

Species	Turbine model	Jul Op.	Aug Op.	Sep Op.	Oct Op.	Nov Op.	Dec Op.
Red Knot	three	86.6 (83.3, 90.2)	86.4 (82.5, 90.1)	87.3 (83.7, 90.9)	89.2 (85.5, 93)	90.4 (86.4, 94)	90.8 (86.9, 94.6)

Results for the SCRAM simulation

Table 8: The predicted mean and 95 perc. prediction intervals of the number of collisions per month and the total summed monthly number of collisions and 95 perc. prediction interval. Results are not shown for months that do not have movement data.

Species	Turbine model	month	Mean number of collisions	Lower pred. interval	Upper pred. interval
Red Knot	three	Jan			
Red Knot	three	Feb			
Red Knot	three	Mar			
Red Knot	three	Apr			
Red Knot	three	May			
Red Knot	three	Jun			
Red Knot	three	Jul			
Red Knot	three	Aug	0.032	0.025	0.04
Red Knot	three	Sep	0.737	0.606	0.882
Red Knot	three	Oct	0.057	0.046	0.068
Red Knot	three	Nov	0	0	0.006
Red Knot	three	Dec			
Red Knot	three	annual	0.826	0.678	0.988



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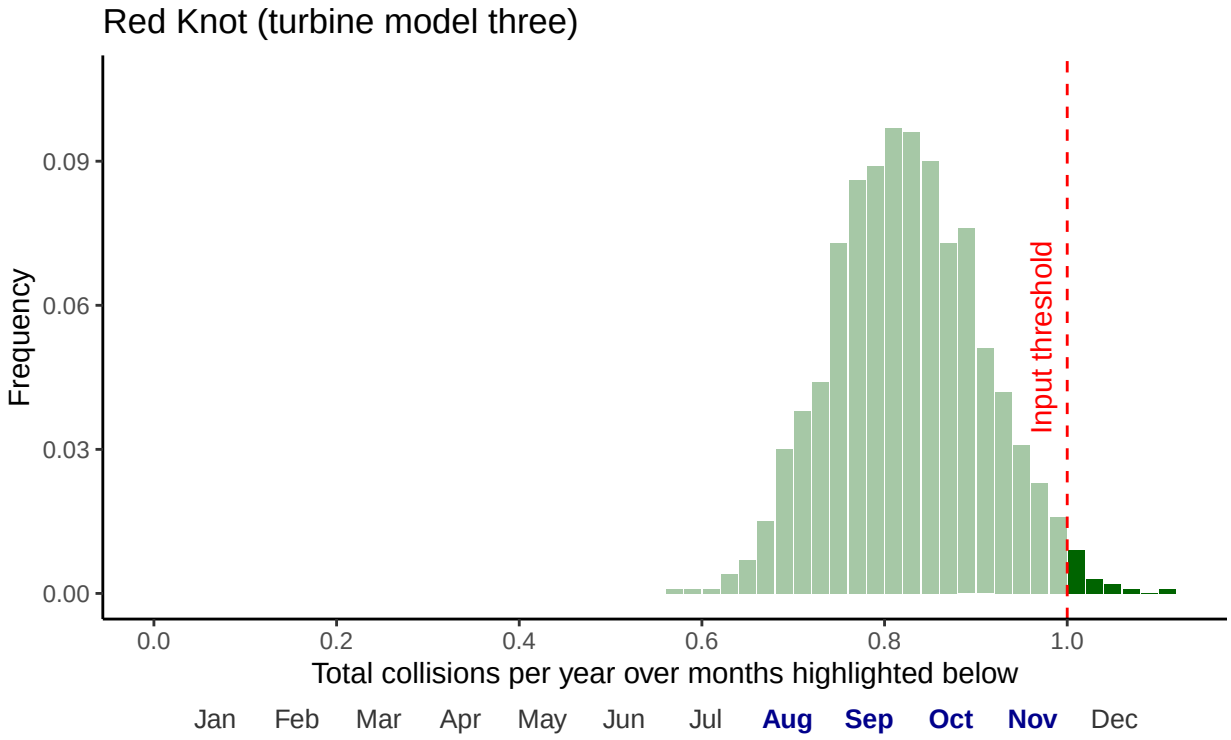

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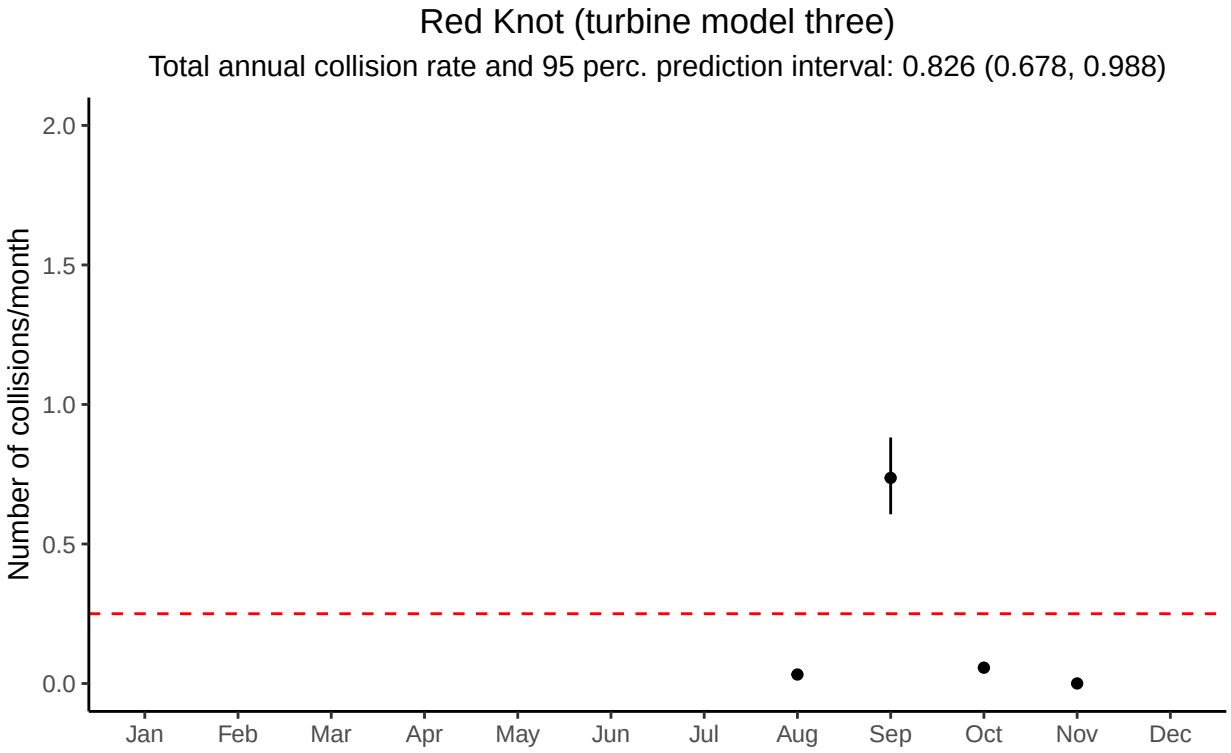

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