Review of Aberdeen Bay Collision Monitoring Data

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1 Executive Summary

This report reviews collision monitoring data collected at Vattenfall's European Offshore Wind Deployment Centre (EOWDC) in Aberdeen Bay between June 2023 and December 2024. The study aimed to quantify bird interactions with offshore wind turbines using a mono-camera system developed by Spoor AI, focusing on turbine AW05 from a camera mounted on AW10. Objectives included summarizing observed bird activity, assessing potential collision events, and comparing findings with pre-construction collision risk estimates.

Over the 19-month monitoring period, the camera system operated reliably, capturing approximately 95% of daylight hours. A total of 2,007 bird tracks were recorded, with activity peaking during the breeding season (June–July) and declining in winter. Birds were typically detected at mid-range distances (250–700 m) and exhibited complex flight paths, with mean speeds of 14.9 m/s and average tracking durations of 26 seconds. These behaviors suggest that individual birds may remain in the wind farm for longer than is assumed in standard collision models, but that exposure at a population level may be lower.

Five potential collision events were flagged but, upon detailed review, none were confirmed. Most involved birds at considerable distances from turbines or exhibiting natural behaviors such as diving. Collision risk modeling based on observed activity predicted fewer than one collision at AW05 over the entire study period (0.002 collisions), aligning with the absence of confirmed events. This contrasts sharply with conservative pre-construction estimates of up to 8.54 collisions per turbine per year under high avoidance assumptions.

Complementary studies at EOWDC, including radar and GPS tracking, corroborate high levels of meso-avoidance behavior, reducing collision risk. Findings emphasize that collisions are rare events and highlight the value of stereoscopic camera systems for improving positional accuracy and reducing false positives.

2 Introduction

The potential for birds to collide with offshore wind turbines has long been recognised as a key concern by regulators, developers and other stakeholders (Garthe & Hüppop 2004; Drewitt & Langston 2006; Furness *et al.* 2013). Whilst it is acknowledged that, on a per turbine basis, collisions are likely to be a rare event, the scale of planned development means that there is still the potential for significant impacts at a population level (Brabant *et al.* 2015; Busch & Garthe 2017). In the onshore environment, substantial effort has been invested in quantifying turbine collision rates, leading to the development of standardised protocols (e.g International Finance Corporation 2023). However, the logistical challenges of working in the marine environment mean that fewer studies are available documenting collision rates with offshore turbines, leading to considerable uncertainty associated with estimates of collision risk.

The need to accurately quantify collision risk to support regulatory processes has led to the development of camera-based monitoring systems designed to collect data on collision rates with offshore wind turbines. One such system, developed by Spoor AI, was deployed at Vattenfall's European Offshore Wind Deployment Centre (EOWDC) in Aberdeen Bay between June 2023 and December 2024. The aim of this study was to collect data on the movements of birds in and around turbines, and to test the capabilities of mono- and stereo-camera setups. The comparison between mono- and stereo-camera set ups, with recommendations for future developments, is reported in Brighton *et al.* (2025).

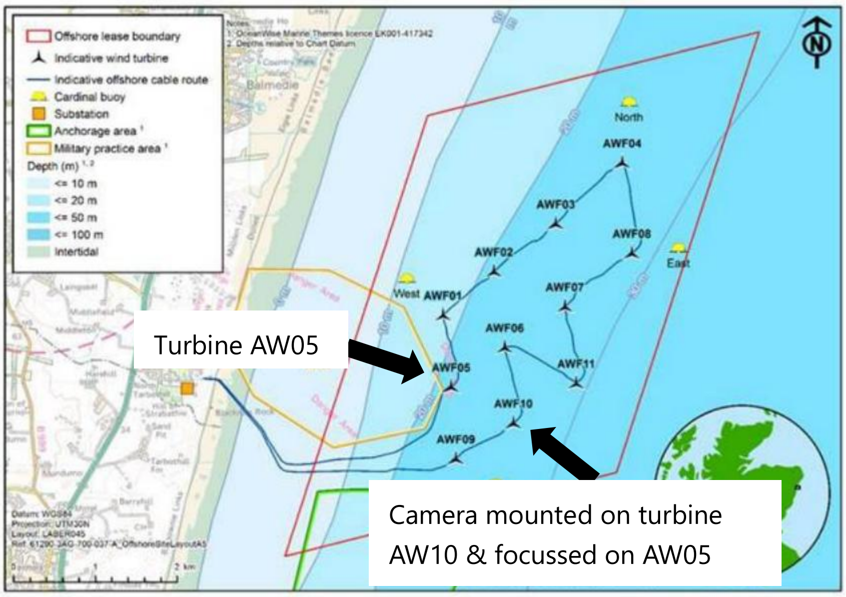

Figure 1 Map of EOWDC Offshore Wind Farm

To complement the Brighton *et al.* (2025) study, we focus on data collected to monitor potential collisions using a mono-camera mounted on turbine AW10 and focussed on turbine AW05, We discuss the movements of birds around the turbine, and the implications of this for collision risk. In particular, we aim to:

- Summarise the data collected
- Describe and discuss potential collision events
- Put the recorded collision rate in the context of pre-construction collision estimates presented in the project Environmental Impact Assessment (EIA)
- Discuss the results in the context of complementary studies at EOWDC
- Consider the potential for confirmed collision data to refine, inform and validate existing approaches to assessing collision risk.

3 Summary of Aberdeen Bay Collision Monitoring Data

3.1 Operational status

Over the course of the study period, the performance of the camera was consistent, with video capturing approximately 95% of the period between dawn and dusk (Figure 2). Whilst there were a few periods of camera down time, these were short in duration. Consequently, the likelihood of collisions being missed as a result of technical issues with the cameras is very low.

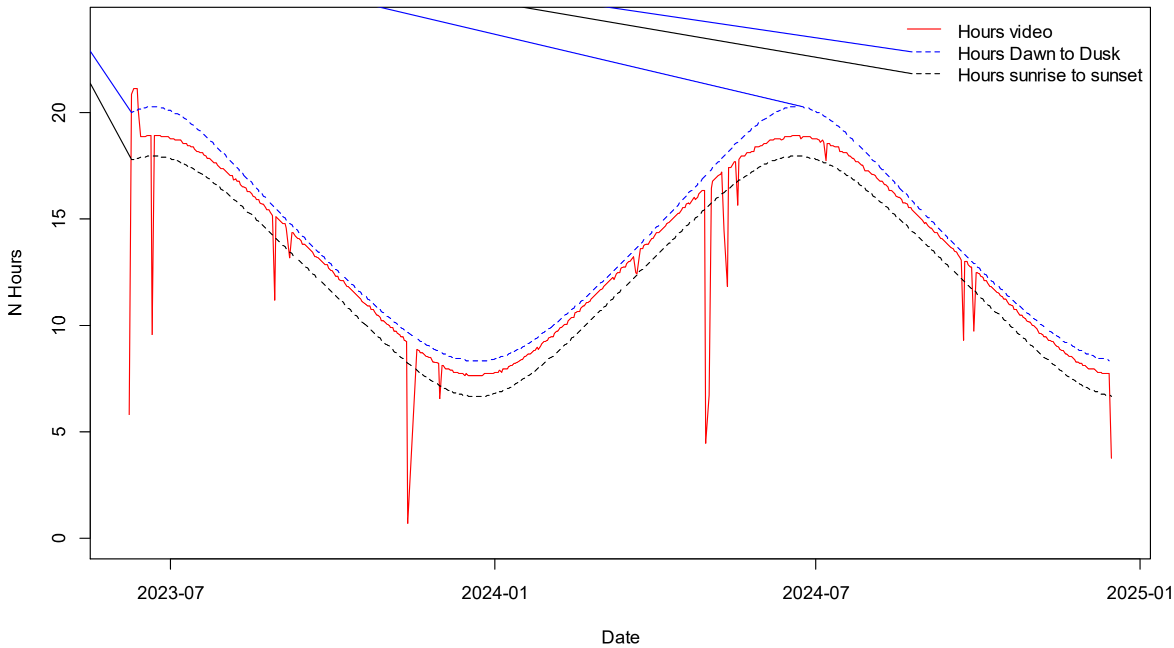

Figure 2 Camera operational status over the study period

3.2 Summary of observations and abundance

Over the course of the study, 2,007 birds were identified as potentially interacting with the turbine, though these were not identified to species level. Comparing between years, monthly estimates of the number of birds recorded were typically greater in 2023 than in 2024 (Figure 3), with a peak of 369 birds recorded in July 2023. In both 2023 and 2024, the greatest number of birds were recorded during the breeding season, in June and July, with fewer recorded over the winter.

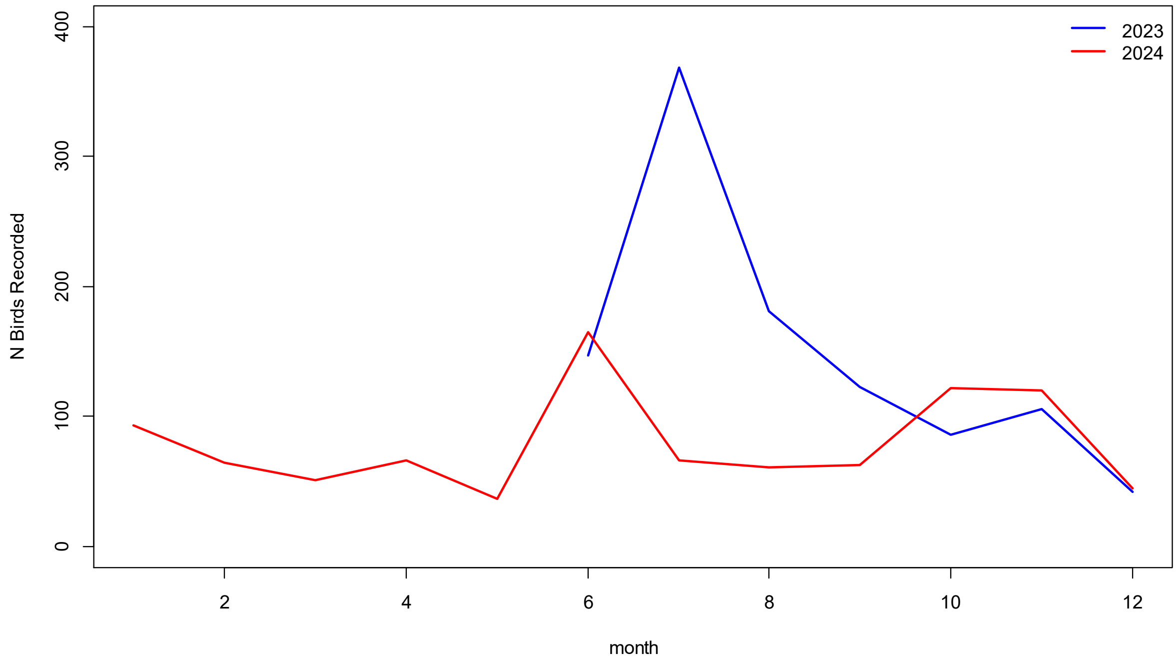

Figure 3 Number of birds recorded per month

3.3 Bird Distribution

In common with Brighton *et al.* (2025), data indicate that detection peaked in the mid-distance ranges, between approximately 250 and 700 m from the camera (Figure 4). Whilst birds were detected beyond this range, and indeed beyond the turbine on which the camera was focussed, it is unclear the extent to which this reflects a reduced detection probability, and the extent to which it reflects a behavioural response to the turbines. May (2015) and Cook *et al.* (2018) suggest that responses at a meso-scale, avoidance of individual turbines, are likely to make a substantial contribution to overall avoidance behaviour. This is supported by empirical data from GPS tracking (Johnston *et al.* 2021; Pollock *et al.* 2024) and radar (Skov *et al.* 2025) studies showing birds avoiding turbines at a distance of approximately 100-200 m.

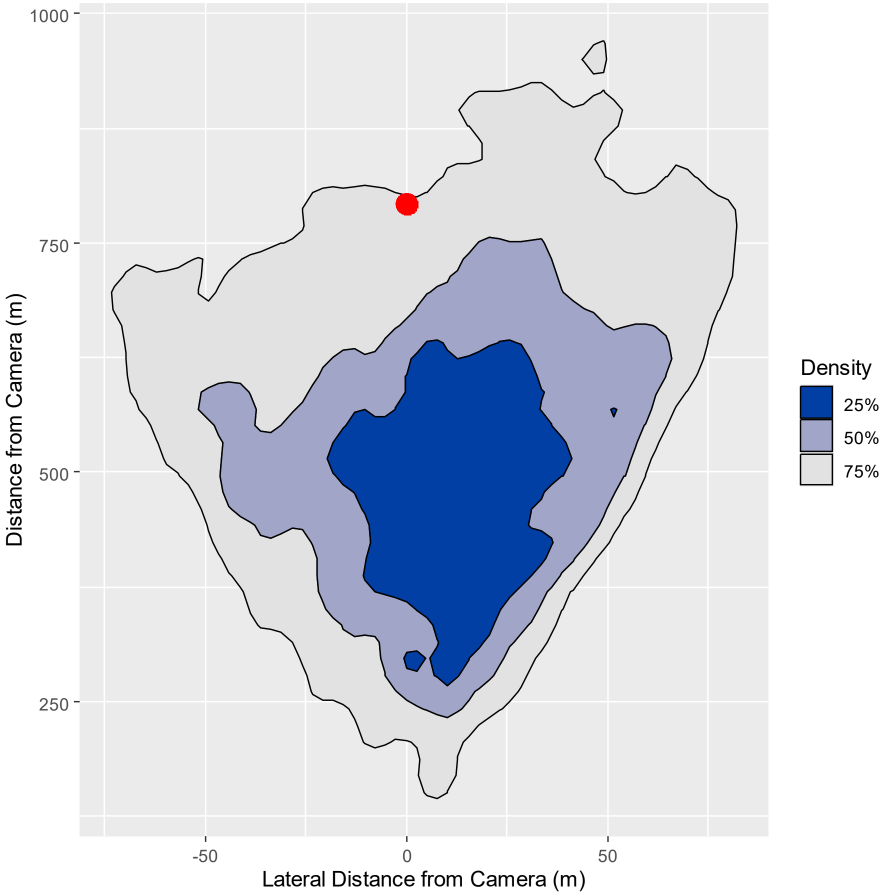

Figure 4 Distribution of birds observed during field study, red dot indicates location of turbine under observation

3.4 Bird movements

Bird position was estimated from mono-vision cameras based on extrapolation from body size (Brighton *et al.* 2025). Birds were tracked for a mean of 26 seconds (SD 15 seconds) (Figure 5), during which they moved over a mean straight line distance of 130 m (SD 103 m) (Figure 6). However, when considering the distance between points, which is a better reflection of the total distance travelled during the period over which birds were recorded, it is clear that birds covered far greater distances, with a mean total distance travelled of 413 m (SD 397 m) (Figure 7). Using these data, the mean speed at which birds are travelling within the wind farm can be estimated at 14.9 m/s (SD 8.37 m/s) (Figure 8), which is consistent with flight speeds previously estimated for species, such as large gulls and Northern Gannets *Morus bassanus*, likely to be present within the wind farm (Alerstam *et al.* 2007).

As previously highlighted in Masden *et al.* (2021), this has implications for how flux rate is estimated in collision risk models. The flux rate F_{tot} is estimated as follows:

$$F_{tot} = D_v \, (\pi R^2) v$$

Where D_v is bird density per m^3, multiplied by the area of the turbine rotor sweep, *R*, and *v,* bird flight speed (Band 2012). This is then multiplied by the total number of seconds that birds are potentially exposed to risk (typically daylight hours + nighttime hours with a correction for nocturnal activity). Implicit in this formula is an assumption that birds are flying in a straight line, perpendicularly to the rotor. Where this is not the case, birds will take longer to pass through the area concerned, meaning that the total number of individual exposed to the risk of collision will be reduced. The data described here clearly suggest that straight line flight within the wind farm is rare, and that therefore, each individual is likely to spend longer within the wind farm. Consequently, whilst individual exposure to collision risk may be greater than would be the case for straight line flight, following the assumptions of the Band (2012) fewer birds overall may be exposed to the risk of collision.

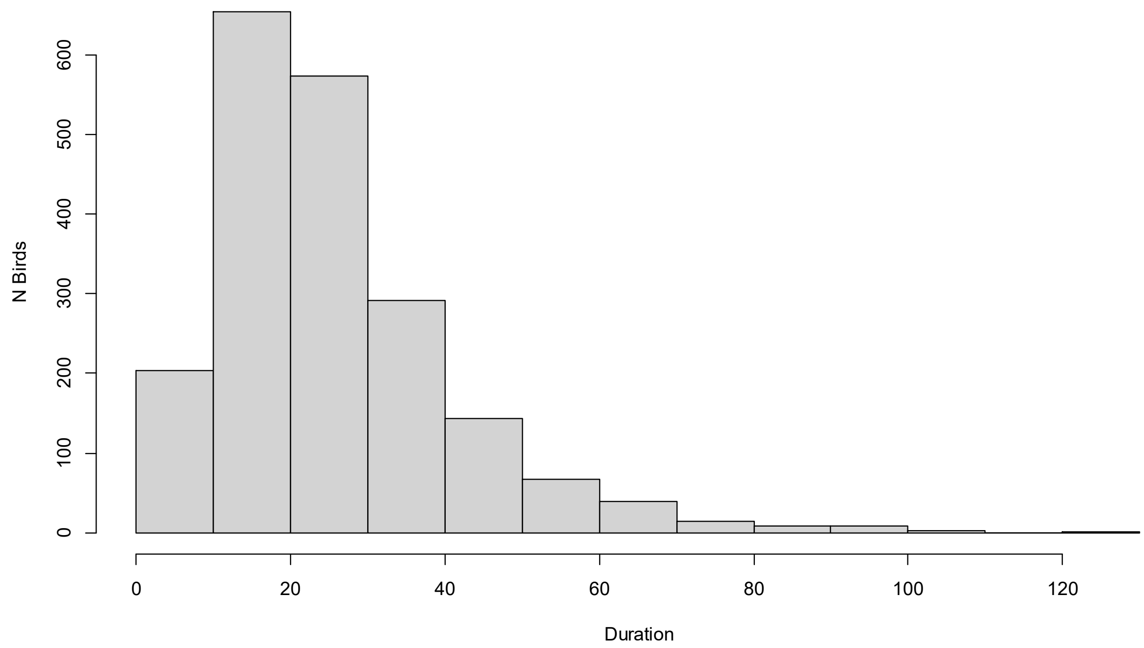

Figure 5 Mean tracking duration of birds (seconds)

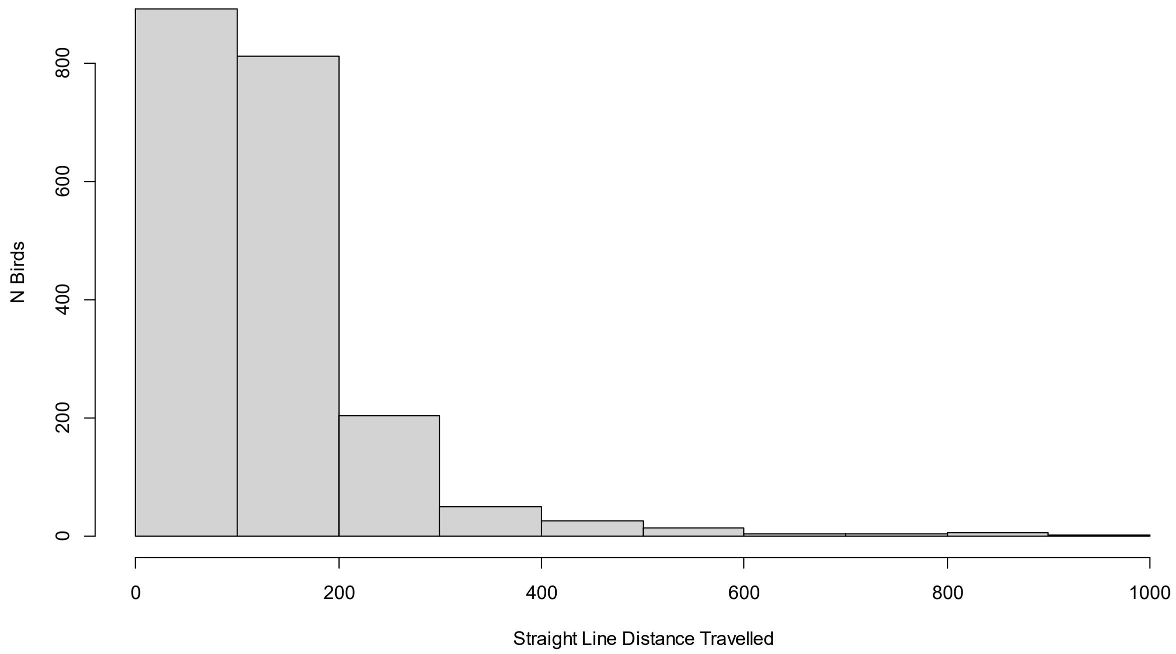

Figure 6 Straight line distance travelled by birds within the wind farm

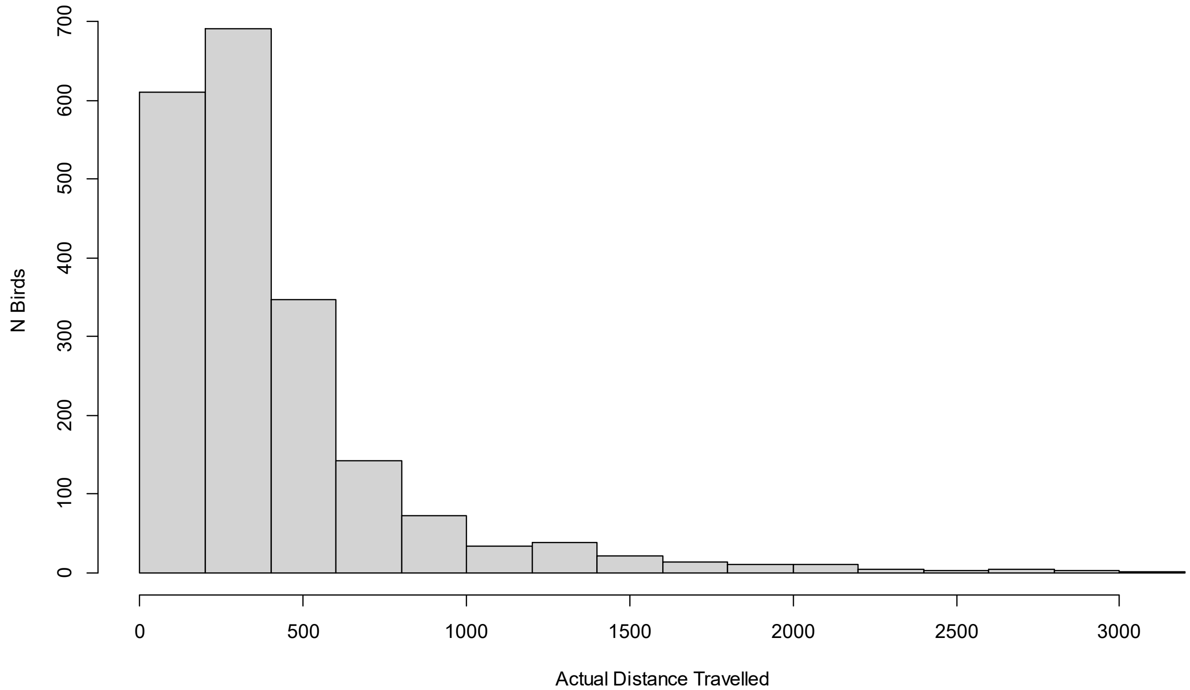

Figure 7 Actual distance travelled by birds within the wind farm

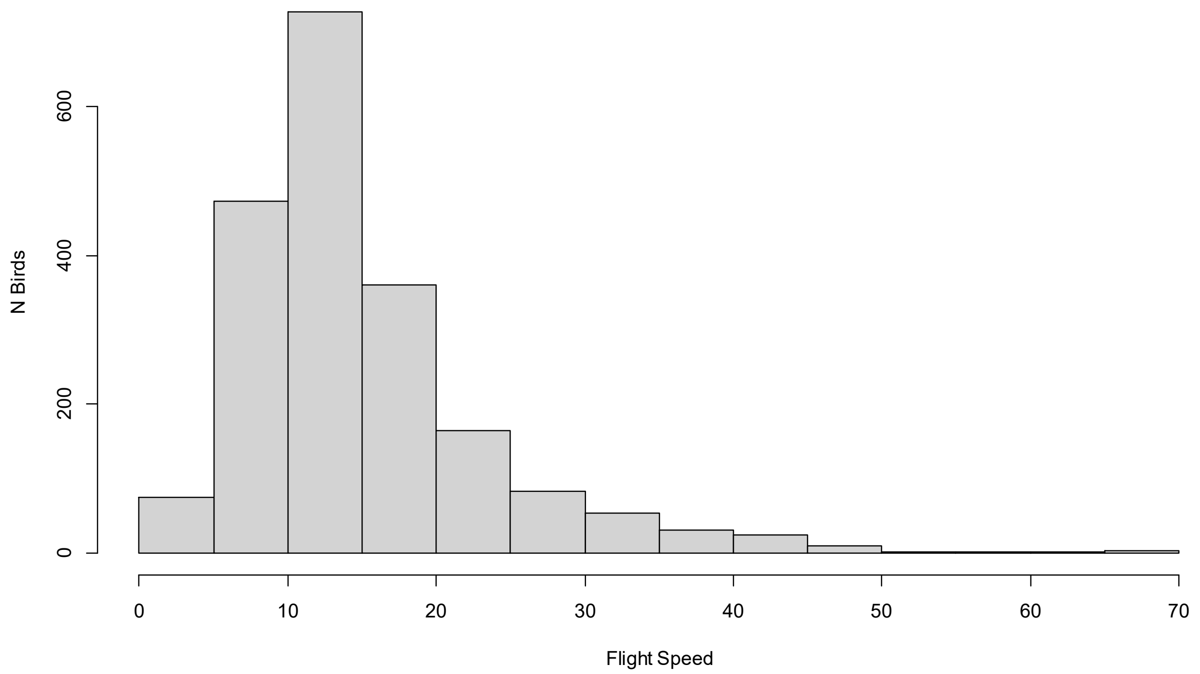

Figure 8 Flight speeds of birds observed within wind farm

3.5 Possible collisions

Of the 2007 tracks collected above, five were flagged as possible collisions. These are described in more detail below. However, in all five cases, careful examination of these videos determined that none related to collisions.

9th June 2023

The clip collected on 9th June 2023 shows a bird passing the turbine travelling from the right of the image to the left (Figure 9). As a turbine blade passed in the background, the bird was observed to show a sudden loss of height, indicating a possible collision. The bird was estimated to be flying at a height of 38-48 m above sea level (Figure 10), potentially within the turbine rotor sweep, and hence at collision risk height. However, closer inspection of the video indicated that the bird was approximately 306 m in front of the turbine at its closest point

Figure 9 Track showing a possible collision on 9th June 2023

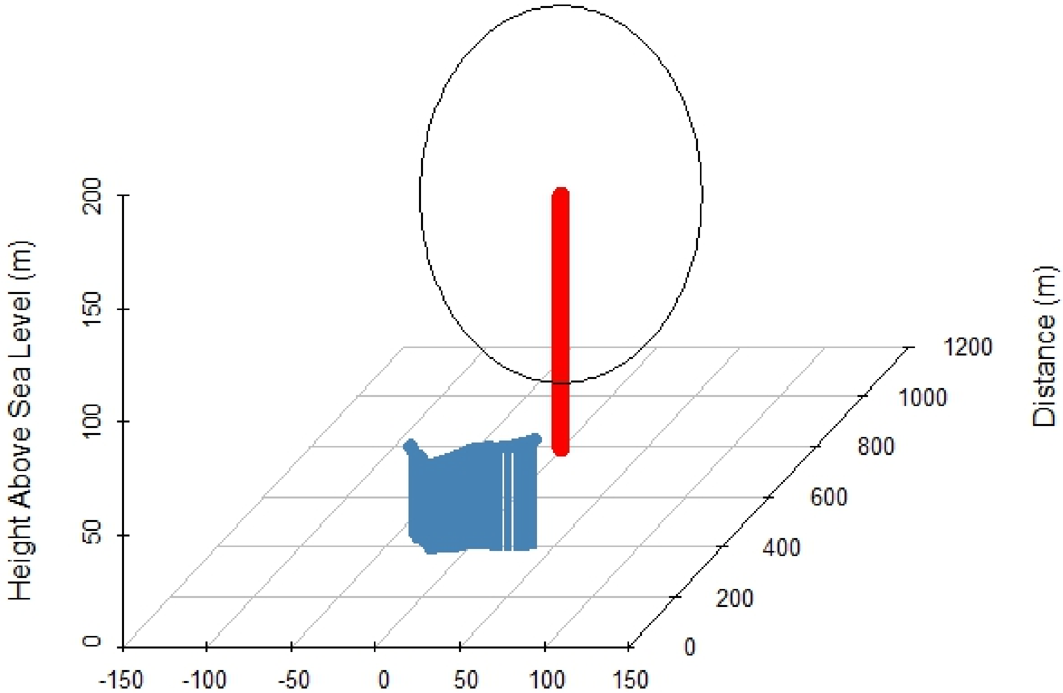

Figure 10 Recreation of bird track collected on 9th June 2023 relative to turbine location

21st August 2023

The clip collected on 21st August 2023 shows a bird passing the turbine travelling from the right of the image to the left (Figure 171). As a turbine blade passed in the background, the bird was observed to show a sudden loss of height, indicating a possible collision. The bird was estimated to be flying at a height of 32-35 m above sea level (Figure 12), potentially within the turbine rotor sweep, and hence at collision risk height. However, closer inspection of the video indicates that the bird is a Northern Gannet and that the sudden change in height is linked to the bird diving for prey. Furthermore, the bird was estimated to be about 290 m from the turbine at it's closest point.

Figure 11 Track showing a possible collision on 21st August 2023

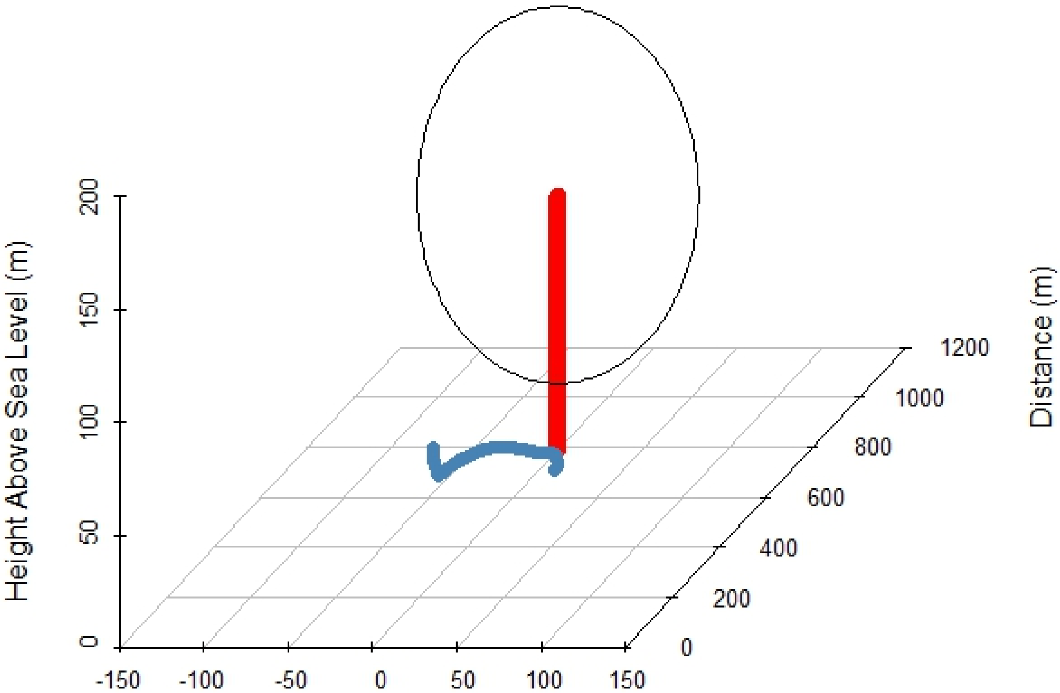

Figure 12 Recreation of bird track collected on 21st August 2023 relative to turbine location

22nd August 2023

The clip collected on 22nd August 2023 shows a bird passing the turbine travelling from the right of the image to the left (Figure 173). As a turbine blade passed in the background, the bird was observed to show a sudden loss of height, indicating a possible collision. The bird was estimated to be flying at a height of 33 m above sea level (Figure 14), potentially within the turbine rotor sweep, and hence at collision risk height. However, closer inspection of the video indicates that the bird is a Northern Gannet and that the sudden change in height is linked to the bird diving for prey. Furthermore, the bird was estimated to be about 650 m from the turbine at its closest point.

Figure 13 Track showing a possible collision on 22nd August 2023

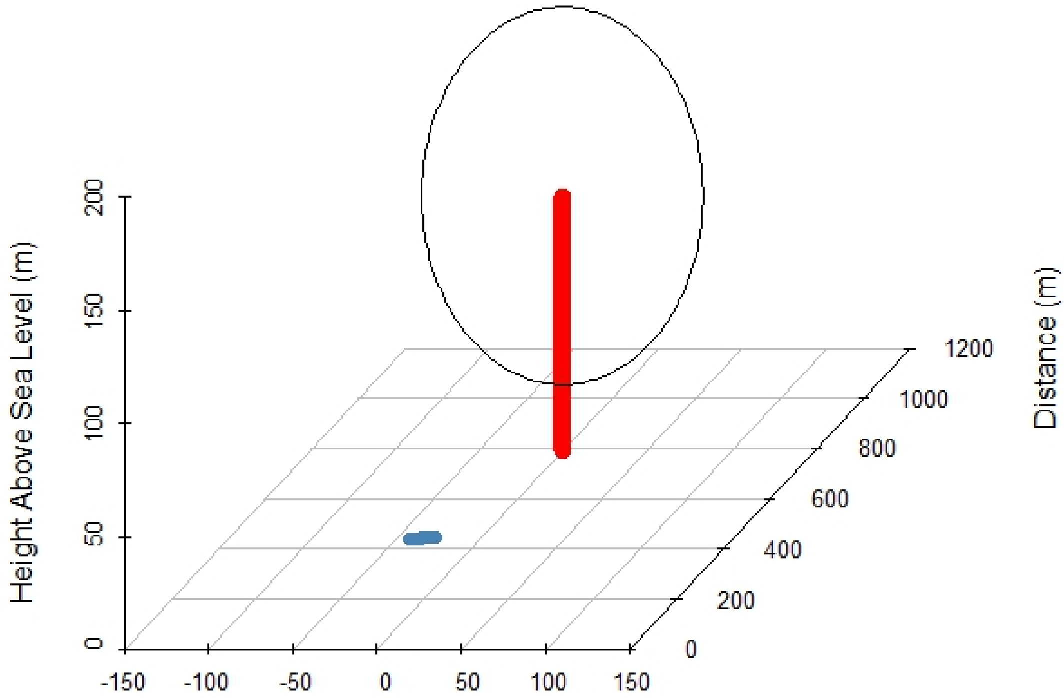

Figure 14 Recreation of bird track collected on 22nd August 2023 relative to turbine location

27th August 2023

The clip collected on 27th August 2023 shows a bird passing the turbine travelling from the right of the image to the left (Figure 175). As a turbine blade passed in the background, the bird was observed to show a sudden loss of height, indicating a possible collision. The bird was estimated to be flying at a height of 44-54 m above sea level (Figure 16), potentially within the turbine rotor sweep, and hence at collision risk height. However, closer inspection of the video indicated that the bird landed on the turbine transition piece, and was then observed to fly off. Whilst the video indicated the bird landing on the transition piece, estimates of distance suggested that the closest it came to the turbine was approximately 170 m. This discrepancy between the observed location of the bird in relation to an object at known distance, and the estimated distance highlights the challenges associated with using size-based approaches to estimating the location of birds discussed in (Boersch-Supan *et al.* 2024).

Figure 15 Track showing a possible collision on 27th August 2023

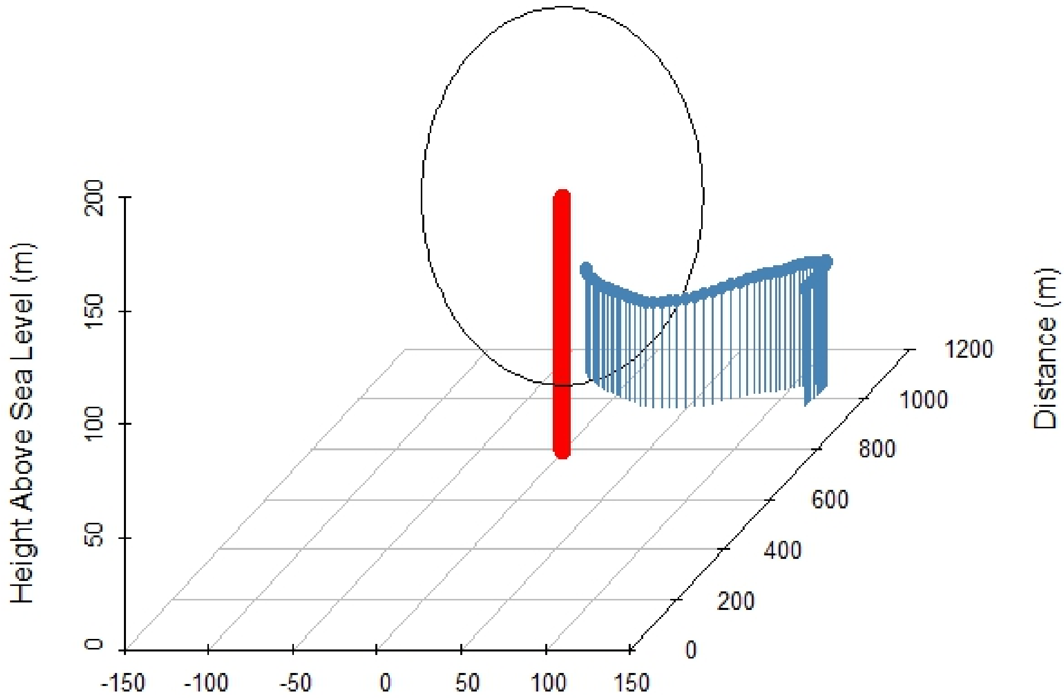

Figure 16 Recreation of bird track collected on 27th August 2023 relative to turbine location

8th September 2024

The clip collected on 8th September 2024 shows a bird passing the turbine travelling from the right of the image to the left, before doubling back (Figure 177). As a turbine blade passed in the background, the bird was observed to show a sudden loss of height (Figure 18), indicating a possible collision. The bird was estimated to be flying at a height of 40-59 m above sea level (Figure 19), potentially within the turbine rotor sweep, and hence at collision risk height. However, closer inspection of the video indicated that the bird was approximately 210 m in front of the turbine at its closest point, and likely to have been diving for food before the camera lost it against the background landscape (Figure 17).

Figure 17 Track showing a possible collision collected on 8th September 2025

Figure 18 Bird shows a sudden loss of height as a turbine blade passes in the background

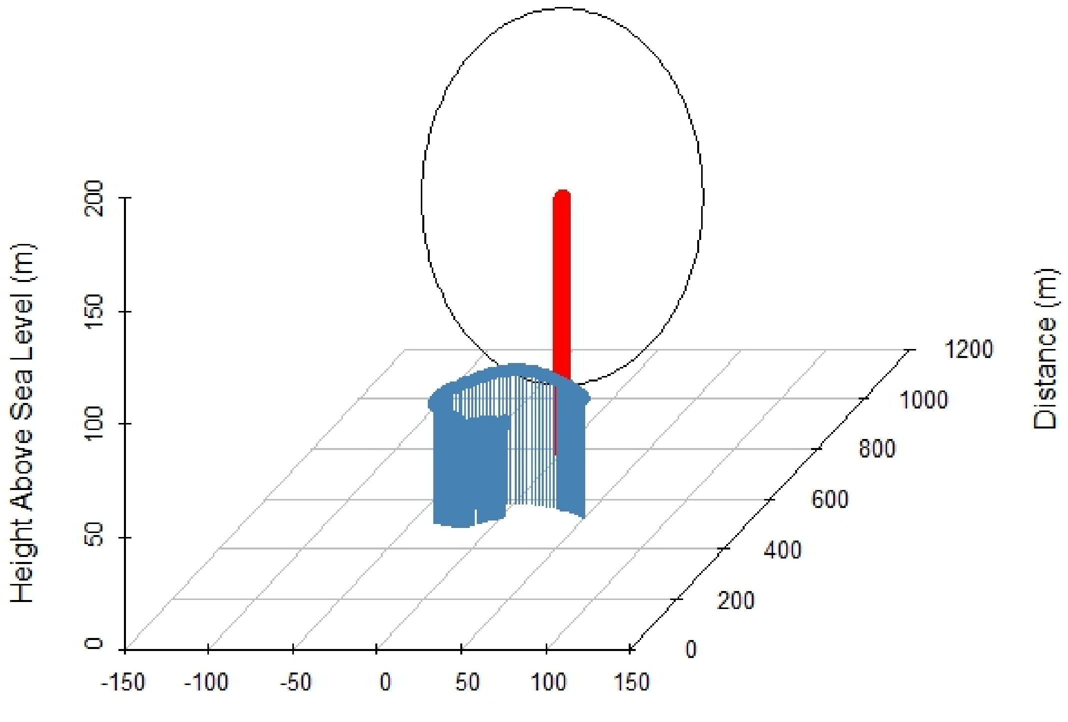

Figure 19 Recreation of bird track collected on 8th September 2024 relative to turbine location

4 Band model collision estimates

4.1 Predictions from EIA

The collision risk assessment conducted for the EIA followed the Band (2012) guidance and Strategic Ornithological Support Services (SOSS) worked examples. The methodology involved six stages: estimating flight activity from monthly boat-based surveys (Stage A), calculating the number of bird flights through turbine rotors using wind farm design, such as number of turbines and rotor radius, and bird flight speed (Stage B), and assessing the probability of collision during a single rotor transit based on bird morphology and turbine specifications (Stage C). These inputs were then used to estimate the expected number of collisions per year (Stage D), incorporating factors such as operational time (assumed at 85%) and a large array correction factor, which was found to have minimal impact. Collision estimates were calculated assuming no avoidance, and then adjusted using avoidance rates of 95%, 98%, 99%, and 99.5% (Stage E), with species-specific rates detailed in the impact assessment.

Uncertainty in the model was addressed in Stage F, recognizing variability in key inputs such as bird density, nocturnal activity, flight height estimates, turbine operation, and model assumptions. For example, bird density was based on monthly means and standard deviations, nocturnal activity carried a 10% uncertainty, and flight height estimates could vary by ±25% due to visual estimation errors. Turbine operation was assumed at 85% monthly, though seasonal variation suggested a ±10% margin. The collision model itself, based on simplifications, was assigned an uncertainty of ±20% following SOSS guidance. These uncertainties were combined to provide a more realistic understanding of the accuracy and reliability of the collision risk estimates.

The collision risk assessment was conducted for all species listed in Table 1. Results indicate that species more prone to collisions are the Black-legged Kittiwake, Common Gull, Herring Gull, Great Black-backed Gull and Northern Gannet. For these species, collision estimates under a 95% avoidance rate ranged from 23 collisions for Northern Gannet to 86 Black-legged Kittiwake. The remaining species had estimates of one or zero collisions. The five species with high collision risks were also among the most abundant overall, and at higher height bands, according to the monthly boat-based surveys data.

As expected, collisions estimates decreased with increasing avoidance rates. For example, estimates for Black-legged Kittiwake dropped to 34, 17, and 9 under 98%, 99%, and 99.5% avoidance scenarios, respectively. Given the species present within the site, recommended avoidance rates would be between 98 and 99.5% (Cook *et al.* 2018), meaning that, across all species, 2.18-8.54 collisions would be expected to be observed per turbine, per year (Table 1).

Table 1: Summary results of collision risk model applying a range of avoidance rates and EOWDC proportion at rotor height and mean predicted collisions for each turbine

	95% Avoidance Rate		**98% Avoidance Rate**		**99% Avoidance Rate**		**99.5% Avoidance Rate**	
	Wind Farm	**Per Turbine**	**Wind Farm**	**Per Turbine**	**Wind Farm**	**Per Turbine**	**Wind Farm**	**Per Turbine**
Guillemot	1 ± 1.49	0.09	0 ± 0.60	0	0 ± 0.30	0	0 ± 0.15	0
Razorbill	1 ± 0.10	0.09	0 ± 0.04	0	0 ± 0.02	0	0 ± 0.01	0
Puffin	0 ± 0.00	0	0 ± 0.00	0	0 ± 0.00	0	0 ± 0.00	0
Fulmar	1 ± 0.78	0.09	0 ± 0.00	0	0 ± 0.00	0	0 ± 0.00	0
Common tern	0 ± 0.76	0	0 ± 0.30	0	0 ± 0.15	0	0 ± 0.08	0
Sandwich tern	1 ± 0.89	0.09	0 ± 0.36	0	0 ± 0.18	0	0 ± 0.09	0
Herring gull	48 ± 48.02	4.36	19 ± 19.02	1.72	10 ± 9.61	0.90	5 ± 4.80	0.45
Black-legged kittiwake	86 ± 69.64	7.81	34 ± 27.86	3.09	17 ± 13.93	1.54	9 ± 6.97	0.81
Great black-backed gull	30 ± 44.58	2.72	12 ± 17.84	1.09	6 ± 8.92	0.54	3 ± 4.46	0.27
Common gull	51 ± 71.58	4.63	20 ± 28.64	1.81	10 ± 14.32	0.90	5 ± 7.16	0.45
Common scoter	0 ± 0.03	0	0 ± 0.01	0	0 ± 0.01	0	0 ± 0.00	0
Eider	0 ± 0.01	0	0 ± 0.00	0	0 ± 0.00	0	0 ± 0.00	0
Shag	0 ± 0.00	0	0 ± 0.00	0	0 ± 0.00	0	0 ± 0.00	0
Cormorant	0 ± 0.42	0	0 ± 0.17	0	0 ± 0.08	0	0 ± 0.04	0
Northern Gannet	23 ± 26.83	2.09	9 ± 10.74	0.81	5 ± 5.37	0.45	2 ± 2.68	0.18
Red throated diver	1 ± 1.76	0.09	0 ± 0.70	0	0 ± 0.35	0	0 ± 0.18	0
Arctic Skua	1 ± 1.06	0.09	0 ± 0.42	0	0 ± 0.21	0	0 ± 0.11	0
TOTAL	**244**	**22.18**	**94**	**8.54**	**48**	**4.36**	**24**	**2.18**

4.2 Revised collision estimates using data from Spoor AI study

To understand the potential change in collision risk following the construction of EOWDC, data collected using the Spoor AI camera system were used to predict the number of collisions that would be expected at turbine AW05.

For the purposes of estimating a collision rate, the flux factor was assumed to be the total number of birds recorded by the cameras on a monthly basis within the approximate field of view of the camera, shown in Figure 20, corrected for the proportion of time for which the cameras were operational (Figure 2), as opposed to extrapolations from bird density. Bird flight speed was estimated to be 14.9 m/s (as estimated above, section 2.4). The proportion of flight activity at collision risk height was estimated as 99.5%. Whilst this is substantially higher than many estimates of the proportion of birds at collision risk height (e.g. Johnston *et al.* 2014), this reflects the orientation of the camera used in the study, which was positioned to focus on the turbine rotor sweep (e.g. Figure 9), and is therefore considered to be representative of the birds detected in this study, and included in estimates of density, but is unlikely to be representative of birds using the area more generally. Given the species likely to be present in the area, an avoidance rate of 98% was used. Morphological parameters were based on black-legged kittiwake as the most abundant species present within the wind farm, and nocturnal activity was assumed to be 0, reflecting the fact that the cameras were only operational during daylight (Table 2). Turbine parameters reflect the turbines present within EOWDC and are presented in Table 3.

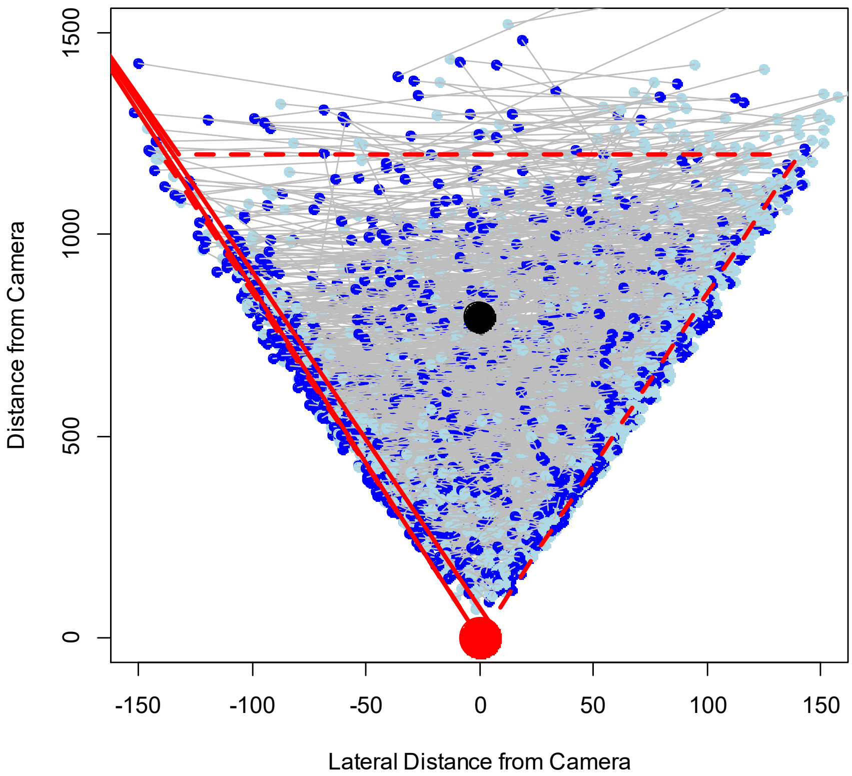

Figure 20 Start (dark blue) and end (light blue) points of all tracks detected during Spoor AI trial at EOWDC. Camera location and approximate field of view shown in red and location of turbine AW05 shown in black. For the purposes of collision risk modelling, densities were estimated on a monthly basis and restricted to tracks with at least one point within the red triangle (e.g. the camera field of view out to a distance of 1,200 m).

Table 2 Bird parameters used for Collision Risk Modelling

	Flux factor	% Collision Risk Height	Flight Speed	Body Length	Wing Span	Nocturnal Activity	Avoidance Rate
June 2023	161	99.5%	14.9 m/s	0.42 m	1.1 m	0	98%
July 2023	386						
August 2023	187						
September 2023	126						
October 2023	87						
November 2023	115						
December 2023	45						
January 2024	99						

February 2024	66						
March 2024	51						
April 2024	67						
May 2024	40						
June 2024	172						
July 2024	67						
August 2024	62						
September 2024	65						
October 2024	125						
November 2024	126						
December 2024	50						

Table 3 Turbine parameters used for Collision Risk Modelling

Number of Blades	3
Rotor Radius	82 m
Blade width	5 m
Rotor pitch	10°
Rotor Speed	12.1 rpm
Hub height	108.5 m
Monthly % operational	85%

The analysis suggests that, given observed levels of bird activity, less than one collision would have been expected at turbine AW05 across the 19 months of the study period (0.002 collisions predicted). This further highlights that collisions are likely to be rare events, and indicates that the lack of collisions detected is to be expected given the observed levels of bird activity.

5 Comparison with previous studies

5.1 DHI Muse Study

Besides the trial of the Spoor AI camera system, EOWDC has been the focus for substantial research aimed at better understanding the impacts of offshore wind farms. One such study was the DHI Muse study, carried out between 2020 and 2021. This study utilised a combined camera-radar system to track the movements of birds in and around turbines, with a view to better understanding seabird behaviour within offshore wind farms, particularly in relation to meso and micro avoidance.

In common with the trial of the Spoor AI cameras at EOWDC, no collisions were detected over the course of the study. Furthermore, the DHI Muse study concluded that rates of micro and meso avoidance were high. Of particular note in relation to the Spoor AI trial are summarised radar tracks which highlight areas of high bird density in the gap between turbines AW05 and AW10, but lower densities closer to the turbines (e.g., Figure 21). This distribution appears consistent with the density of birds detected between the two turbines in the Spoor AI trial (Figure 4).

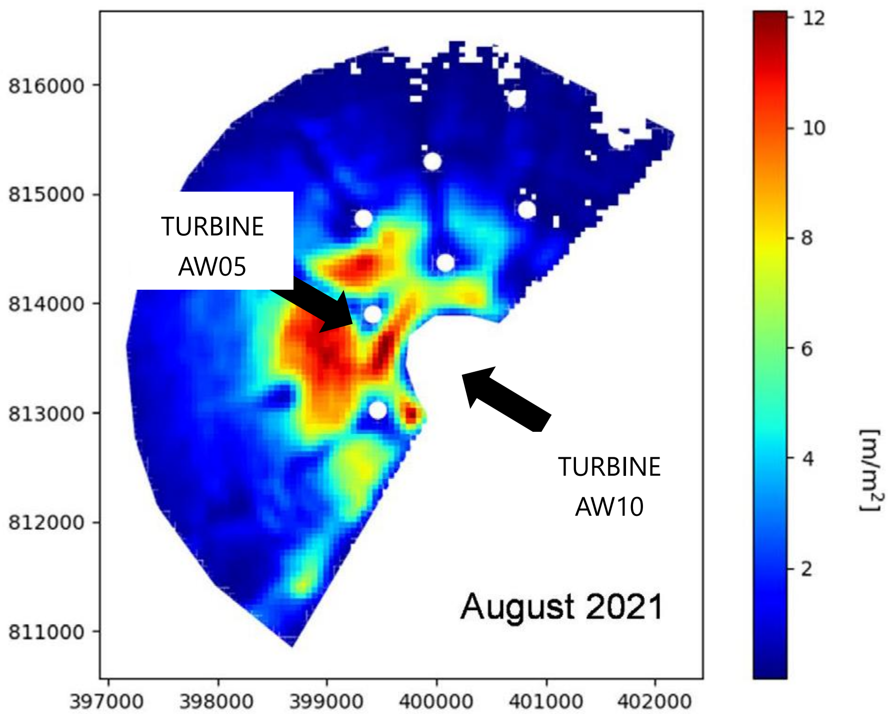

Figure 21 Radar tracks collected from EOWDC during the DHI Muse study in August 2021 from Skov et al. *(2025)*

5.2 BTO GPS Tracking Study

Pollock *et al.* (2024) investigated the avoidance behaviour of black-legged kittiwake, the most commonly observed species at EOWDC in pre-construction surveys, in relation to three offshore wind farms in North East Scotland, including EOWDC. In common with both the Spoor AI trial and the Muse DHI Study, this work indicated high levels of meso-avoidance within wind farms at distance of up to 140 m from turbines (Figure 18).

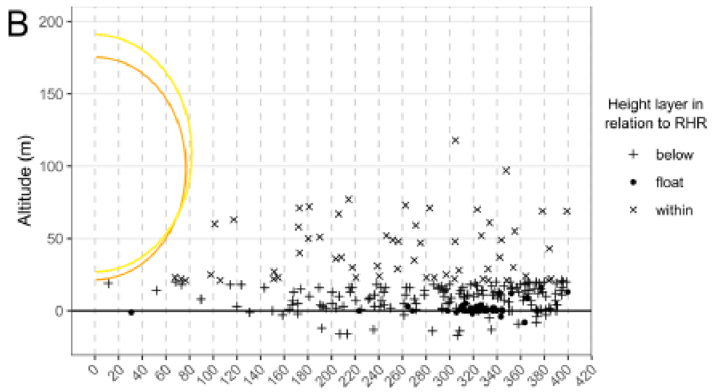

Figure 22 Black-legged kittiwake GPS data collected from three wind farms in the North East of Scotland indicative of avoidance of turbine rotor sweeps at distances of up to 140 m (Pollock et al. *2024).*

6 Conclusions and Recommendations

No collisions were detected during the Spoor AI trial at EOWDC. Consideration of collision risk modelling carried out in support of the EIA suggested that, using conservative assumptions, up to 8.54 collisions may be expected per turbine per year. However, when those conservative assumptions were applied to data collected during the Spoor AI trial, less than one collision was predicted over the 19 months of the study. Consequently, it is unsurprising that no collisions were detected.

Collisions are rare events, consequently a conservative approach is needed to identify videos containing potential collisions. This is likely to result in a high false positive rate. Even accounting for the uncertainties associated with size-based methods for estimating the position of birds, several of the potential collision flagged here were at a considerable distance from the turbine, and hence not at risk of collision. The move to estimating the location of birds using stereoscopic cameras, as opposed to size-based methods, is likely to offer greater precision in identifying potential collision events, reducing the false positive rate.

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7 References

Alerstam, T., Rosén, M., Bäckman, J., Ericson, P.G.P. & Hellgren, O. (2007) Flight Speeds among Bird Species: Allometric and Phylogenetic Effects. *PLoS Biology* 5: e197.

Band, B. (2012) Using a collision risk model to assess bird collision risks for offshore windfarms. *SOSS report, The Crown Estate*.

Boersch-Supan, P.H., Brighton, C.H., Thaxter, C.B. & Cook, A.S.C.P. (2024) Natural body size variation in seabirds provides a fundamental challenge for flight height determination by single-camera photogrammetry: a comment on Humphries et al. (2023). *Marine Biology* 171: 122.

Brabant, R., Vanermen, N., Stienen, E.W.M. & Degraer, S. (2015) Towards a cumulative collision risk assessment of local and migrating birds in North Sea offshore wind farms. *Hydrobiologia* 756: 63–74.

Brighton, C.H., Clarke, J.A. & Boersch-Supan, P.H. (2025) Scientific support to the trial of Spoor AI at the European Offshore Wind Deployment Centre (No. 781). British Trust For Ornithology, Thetford. https://www.bto.org/sites/default/files/RR%20781%20Brighton%20et%20al%202025%20Spoor%20AI.pdf

Busch, M. & Garthe, S. (2017) Looking at the bigger picture: the importance of considering annual cycles in impact assessments illustrated in a migratory seabird species. *ICES Journal of Marine Science*.

Cook, A.S.C.P., Humphreys, E.M., Bennet, F., Masden, E.A. & Burton, N.H.K. (2018) Quantifying avian avoidance of offshore wind turbines: Current evidence and key knowledge gaps. *Marine Environmental Research* 140: 278–288.

Drewitt, A.L. & Langston, R.H.W. (2006) Assessing the impacts of wind farms on birds. *Ibis* 148: 29–42.

Furness, R.W., Wade, H.M. & Masden, E.A. (2013) Assessing vulnerability of marine bird populations to offshore wind farms. *Journal of Environmental Management* 119: 56–66.

Garthe, S. & Hüppop, O. (2004) Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. *Journal of Applied Ecology* 41: 724–734.

International Finance Corporation (2023) Post-construction bird and bat fatality monitoring for onshore wind energy facilities in emerging market countries. Good practice handbook and decision support tool. https://www.ifc.org/content/dam/ifc/doc/2023/handbook-post-construction-bird-bat-fatality-monitoring-onshore-wind-ems.pdf

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M. & Burton, N.H.K. (2014) Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. *Journal of Applied Ecology* 51: 31–41.

Johnston, D., Thaxter, C., Boersch-Supan, P., Humphreys, E., Bouten, W., Clewley, G., Scragg, E., Masden, E., Barber, L., Conway, G., Clark, N., Burton, N. & Cook, A. (2021) Investigating avoidance and attraction responses in lesser black-backed gulls Larus fuscus to offshore wind farms. *Marine Ecology Progress Series*.

Masden, E.A., Cook, A.S.C.P., McCluskie, A., Bouten, W., Burton, N.H.K. & Thaxter, C.B. (2021) When speed matters: The importance of flight speed in an avian collision risk model. *Environmental Impact Assessment Review* 90: 106622.

May, R.F. (2015) A unifying framework for the underlying mechanisms of avian avoidance of wind turbines. *Biological Conservation* 190: 179–187.

Pollock, C.J., Johnston, D.T., Boersch-Supan, P.H., Thaxter, C.B., Humphreys, E.M., O'Hanlon, N.J., Clewley, G.D., Weston, E.D., Shamoun-Baranes, J. & Cook, A.S.C.P. (2024) Avoidance and attraction responses of kittiwakes to three offshore wind farms in the North Sea. *Marine Biology* 171: 217.

Skov, H., Tjørnløv, R.S., Armitage, M., Barker, M., Jørgensen, J.B., Mortensen, L.O. & Uhrenholdt, T. (2025) High-resolution multi-sensor technology reveals low collision risk to seabirds in offshore wind farms. *Journal of Applied Ecology* n/a: e70239.