Precision and bias of bird fatality estimates from two contrasting carcass detection strategies

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Introduction

Carcass monitoring at operational onshore wind farms is expensive. The high labour costs involved means there is little incentive for wind farm operators to collect data on bird collisions without obligation to do so. Yet quantifying bird mortality from systematic carcass searches could provide a valuable evidence-base with which to understand impacts at regional and national scales, validate pre-consent collision risk assessments, and inform future consenting decisions such as repowering.

So what if carcass searches could be carried out incidentally during routine turbine inspections? If data could be collected at lower cost it may lead to greater uptake within the industry. This leads to the question of how, given a limited amount of effort, should a search be conducted? Would it be preferable to search a smaller area with higher frequency or a larger area with lower frequency? Here we use data simulations to compare the precision and bias of fatality estimates resulting from two contrasting carcass detection strategies: Method A involves weekly searches of turbine hardstandings; Method B involves monthly searches of a 50m radius of turbines (Table1; Fig. 1).

Table 1: Method-specific specific parameters used in simulation exercise.

Method	Search interval	Search area
A	7 days	2400m^2
B	30 days	7854m^2

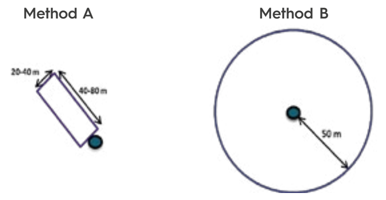

Fig. 1: Contrast in search areas between methods.

Methods: parameterising data simulations

Not all bird carcasses resulting from turbine collisions will be found. The probability a carcass will be detected during a search is influenced by various biases (see below), which need to be parameterised before the number of fatalities can be estimated. We conducted a full literature review to determine suitable values for each bias to use in data simulations.

Bias 1: Some carcasses fall outside the searched area.
The proportion of carcasses that fall within the search area depends on how far they are thrown on collision, which depends on the size and speed of the turbine and the bird.

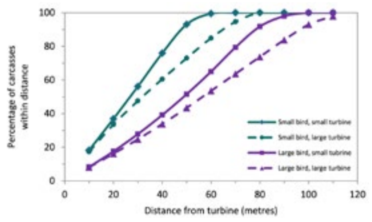

Fig. 2: Proportion of carcasses falling within distance of turbines.

Bias 2: Some carcasses are removed by scavengers.
The proportion of carcasses that remain from time of death until the next carcass search depends on the density and diversity of vertebrate and invertebrate scavengers in the area.

Fig. 4: Predator removal trials are used to determine probability a carcass will persist. Here the condition of a buzzard Buteo buteo carcass is shown at Day 0 (left) and Day 14 (right) after being partially removed by invertebrate scavengers.

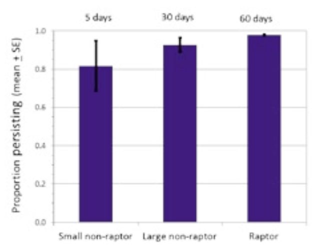

Fig. 3: Average persistence probabilities published in the literature.

Bias 3: Some carcasses are not found by observers.
The proportion of carcasses found during searches is influenced by observer experience, carcass type, carcass size, level of carcass decay, surrounding habitat, and weather.

Fig. 6: Searcher efficiency trials are used to determine probability observers will find a carcass. Here the difference in detectability of a buzzard carcass hidden in heath (left) or in grassland (right) is demonstrated.

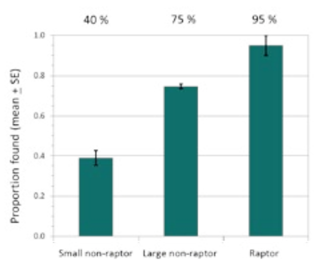

Fig. 5: Average searcher efficiencies published in the literature.

Methods: data simulation and fatality estimation

We extracted plausible rates for biases from the literature to input into simulation scenarios for different bird groups: large raptors, small raptors, large non-raptors and small non-raptors (Table 2). For each bird group we assumed three annual mortality rates (1, 5, and 10 fatalities per year) and four monitoring durations (1, 5, 10 and 25 years). One thousand simulations were run for each scenario (Fig. 7) and the bias and precision of fatality estimates resulting from both methods calculated using the Korner-Nievergelt fatality estimator. A sensitivity analysis was also conducted to see how searcher efficiency and carcass persistence influenced detection probability.

Table 2: Bird-specific parameters from the literature used in simulation exercises.

Bird group	Searcher efficiency	Persistence probability	Proportion in search area
Large raptors and gulls	1.00	0.983	0.520
Small raptors	0.75	0.946	0.725
Swans and geese	0.75	0.994	0.520
Waders and galliformes	0.65	0.930	0.725

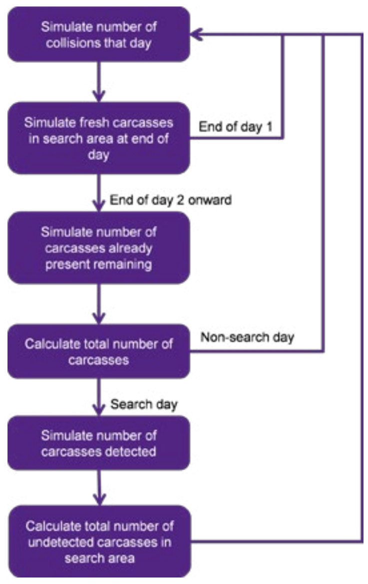

Fig. 7: Simulation procedure for each day of each simulation.

Results: bias and precision of fatality estimates

- → Fatality estimates from Method B were more precise and less biased than those from Method A when carcass persistence probability and searcher efficiency were high, such as raptors and large non-raptors (Fig. 8)
- → Estimates from both methods were equally biased and imprecise when carcass persistence probability and searcher efficiency were low, such as small non-raptors, particularly when monitoring lasted for < 5years.
- → When annual mortality rates were low (< 1 fatality per year) both strategies produced biased and imprecise fatality estimates unless monitoring continued for > 10 years. The exception being when using Method B for birds with high persistence and search efficiency (raptors and large non-raptors), which could be detected with reasonable accuracy and precision even when mortality rates were low.
- → When annual mortality rates reached > 5 fatalities per year accurate estimates were attained after 5 years of monitoring using either method.

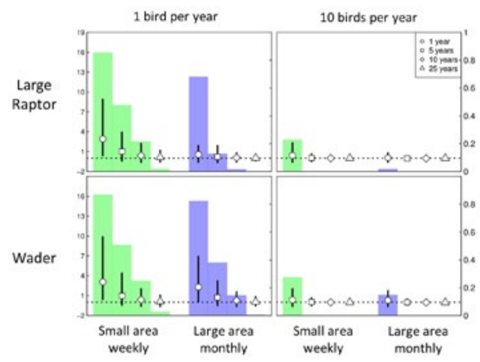

Fig. 8: Bias (points) and precision (error bars) of fatality estimates. Dashed reference line indicates perfect estimates. Values above this represent over-estimates and those below represent under-estimates. The proportion of simulations in which no carcass were detected (bars) is also shown.

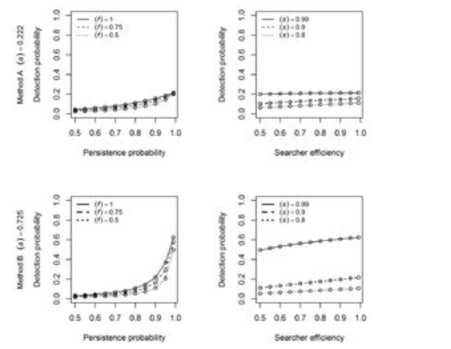

Fig. 9: Sensitivity of detection probability to persistence probability (f: left) and searcher efficiency (s: right). Top row shows Method A with a smaller proportion of carcasses falling in search area than Method B (bottom row).

Results: sensitivity analysis

- → Searcher efficiency had little influence on detection probability (Fig. 9: right).
- → Persistence probability had little influence on detection probability in Method A (Fig. 9: left top), persistence probabilities > 0.9 had a strong effect on detection probability in Method B (Fig. 9 bottom).
- → The difference in the sensitivity of detection probability between methods is due to the difference in the proportion of carcasses falling within the search area, which acts as a direct multiplier on detection probability.
- → Accurate calculation of the proportion of carcasses falling with a search area is crucial in determining the correct probability of detection.

Conclusions

- → Both methods could provide useful fatality estimates depending on the particular species of interest, duration of monitoring, and expected annual mortality rates.
- → Both had similarly high precision and accuracy when monitoring lasted > 10 years and/or when mortality rates were > 10 collision per year regardless of species.
- → Accuracy and precision of both methods decreased when monitoring was < 5 years duration and/or collision rates were < 1 per year, particularly for small non-raptors.
- → Method B is likely to provide slightly better estimates for raptors and large non-raptors with high persistence and search efficiency rates. This pattern could well be reversed if species of interest had low persistence probabilities.

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