Technical Appendix 8.4

Bat Mitigation and Monitoring Plan

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8.1 Introduction

1. The assessment of bat activity at Arecleoch Extension Windfarm (the proposed Development) concluded that pipistrelle bats (both common pipistrelle Pipistrellus pipistrellus and soprano pipistrelle Pipistrellus pygmaeus, hereafter referred to as *"pipistrelle bats"*) are present in sufficient abundance that the development is considered to pose a Medium risk to these bat populations (**Technical Appendix 8.3A**).

2. As such mitigation measures are required to reduce the risk to bats during windfarm operation. This document describes the mitigation measures, method of implementation, auditing and monitoring programme which will be implemented during the operational phase of the proposed Development. It also describes the process by which any changes to mitigation measures will be made as part of feedback from monitoring data.

8.2 Mitigation Measures

3. Although the relationship between recorded bat activity and fatalities at windfarm sites in the UK remains unclear[1], SPR is able to infer this relationship to some extent by comparing activity data recorded at the proposed Development to that collected from operational projects in the same region (i.e. south-west Scotland) which have a known rate of bat fatalities.

4. SPR has conducted detailed acoustic and fatality monitoring of bats at 10 operational windfarms and acoustic monitoring aligned to the 2019 SNH guidance[2] at 3 development phase projects. This combined dataset comprises data collected at 71 unique locations with static bat detectors deployed for a total of 1710 nights, providing a total sample size of 9367 detector nights of bat activity (sample unit = 1 detector / night) after some samples were removed due to equipment failure. Of these, 7269 samples are from 9 projects in south-west Scotland and were used for the analysis.

5. Carcass surveys have been undertaken at all 10 of the operational windfarms using methods consistent with the DEFRA study. Of these, 6 were found to have zero bat fatalities, 2 had an *"incidental"* rate of fatality (considered to be <2 bat fatalities / turbine / year) and 2 had fatality rates greater than 2 bat fatalities / turbine / year.

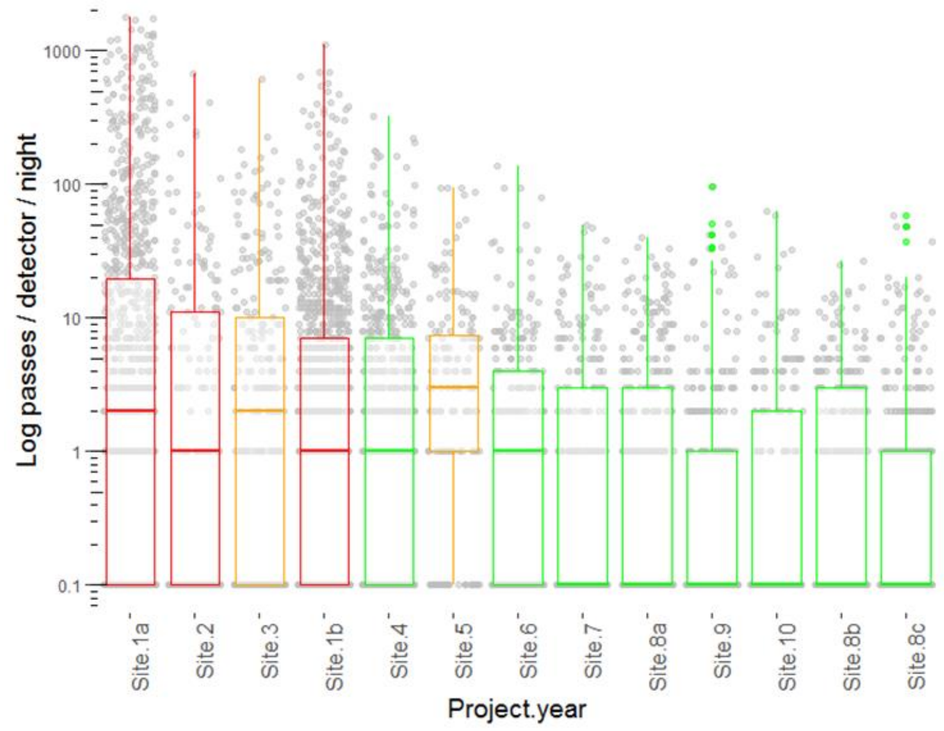
6. The data collected at the 10 operational windfarms indicates a relationship between bat activity and the rate of fatality. Graph 1 shows the 10 operational sites ranked by bat activity and colour coded by the category of fatality rate. Sites with higher activity tended to have higher rates of fatality.

7. This dataset can be used as a reference for new projects by providing a comparison of bat activity within a region in a similar manner to EcoBat, but in addition it can benchmark activity rates for new projects against activity rates of sites with a known rate of bat fatality.

8. Graph 2 shows the number of pipistrelle bat passes per location per night at different percentiles compared to the same values derived from operational projects with different categories of bat fatality. From these data it is expected that the bat activity at the proposed Development will generate a fatality rate between zero and incidental as the activity level falls between these two benchmarks at each percentile.

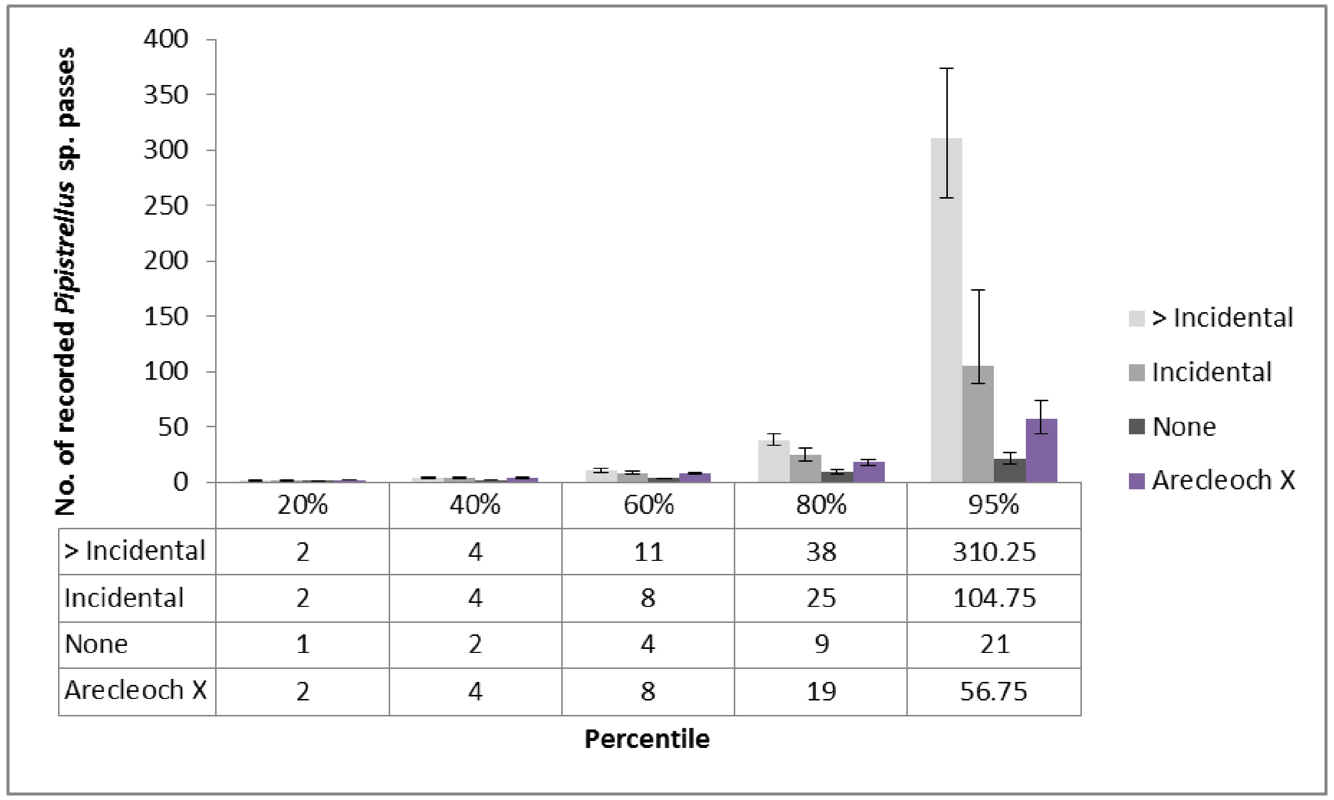
9. Since the predicted bat fatality rate for pipistrelle bats is expected to be incidental or less, the mitigation measures will comprise curtailment of the operation of the wind turbines while they are idling i.e. below the cut-in wind speed at which electricity generation occurs. The mitigation measures will be implemented at each turbine between the months of April - October between sunset and sunrise each year for the lifetime of the proposed Development unless monitoring results necessitate a change.

10. The predicted activity rate for Nyctalus bats is low, therefore no additional mitigation is considered to be required for these species.



Graph 1: Operational windfarm sites ranked left to right in descending order of bat activity (recorded July – September), shown both as box plots of the overall dataset and individual samples as grey points. Red sites had >2 fatalities / turbine / year; amber sites had <2 fatalities / turbine / year; green sites had zero fatalities detected. The data only includes Pipistrelle and Nyctalus species.

[1] Mathews, F., S. Richardson, P. Lintott and D. Hosken (2016). Understanding the Risk to European Protected Species (bats) at Onshore Wind Turbine Sites to inform Risk Management. DEFRA, UK.
[2] SNH (2019). Bats and Onshore Wind Turbines: Survey, Assessment and Mitigation.



	20%	40%	60%	80%	95%
> Incidental	2	4	11	38	310.25
Incidental	2	4	8	25	104.75
None	1	2	4	9	21
Arecleoch X	2	4	8	19	56.75

Graph 2: Number of pipistrelle bat passes per night per location at different percentiles compared to operational projects with a known category of bat fatality. Error bars are 95% CIs derived using bootstrap methods due to non-normal distribution of the datasets.

8.3 Implementation

11. The implementation of the mitigation will be via software which will automatically send a *"pause"* command to the relevant turbine when the parameters are met, initiating a feathering of the blades to the fully open position using the pitch controls and disengagement of the generator. This will slow the rotation speed of the blades to below 1 RPM (i.e. slower than the second hand of a clock). The emergency braking system shall not be used.

12. The wind speed will be obtained from each turbine anemometry apparatus (on the nacelle) via the Supervisory Control and Data Acquisition (SCADA) interface. The control software will run within the proprietary SPR Centre of Operation of Renewable Energy (CORE) system.

13. This method of control has already been established and is used for another SPR windfarm, Plate 1 is a screenshot of the parameter input window for this project within CORE. Note that the example includes a parameter for temperature which can be used if curtailment is required, as well as offsets for sunset and sunrise if required.

14. Note that in the example of Plate 1 there is a *"Speed Lo limit"* of 5.5 m/s, below which the turbine would enter a *"pause"* state, and a *"Speed Hi Limit"* of 5.6m/s above which the turbine would *"run"*. The reason for this is to stop the turbine rapid cycling between *"pause"* and *"run"* when the wind speed is averaging 5.5 m/s. In practice, the *"Speed Hi Limit"* is likely to be 0.5 m/s higher than the selected curtailment speed to prevent this cycling damaging the turbine (which slightly increases the time which the turbine is curtailed). In practice these values would be set specifically for the turbines at the proposed Development according to the manufacturers generation speed, typically around 4 m/s.

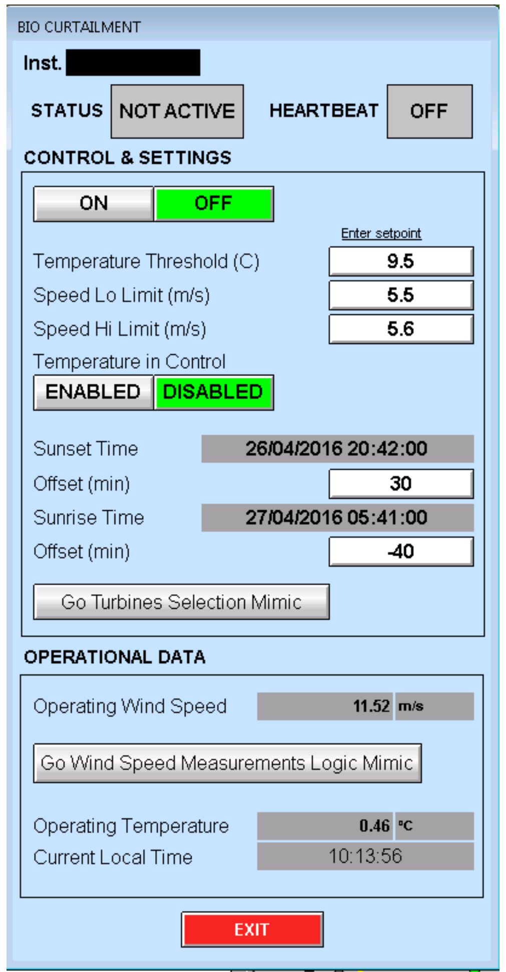
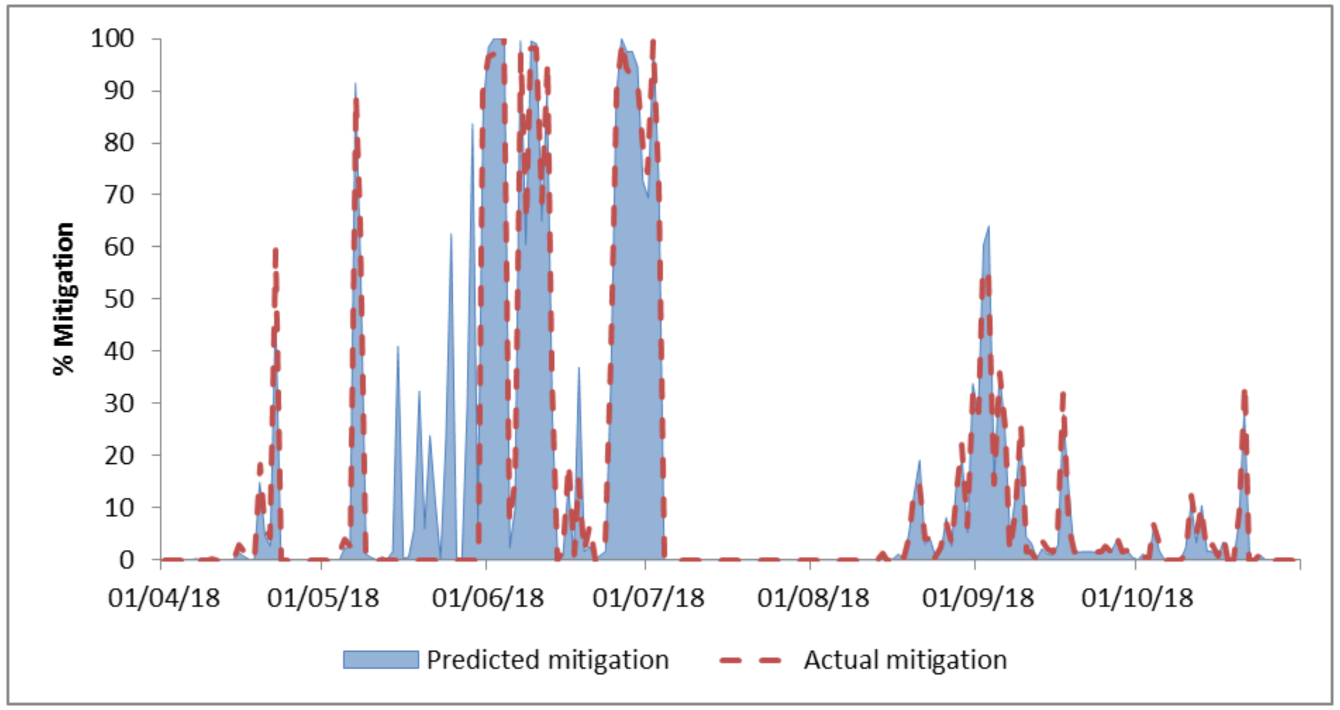


Plate 1: Screenshot of the curtailment parameter input window within CORE in use for another SPR windfarm.

8.4 Auditing

15. All turbine sensor data reported via SCADA is logged in a PI database[3]. This includes the wind speed and temperature data recorded at each turbine anemometry, as well as a TRUE/FALSE flag as to whether the mitigation system was in operation. As such it is a simple process to download the data over any period to validate that the system was operating according to the chosen parameters. An example of this output for another SPR windfarm is displayed in a graphical format in Graph 3. A similar output would be included in the annual report of the system operation for the proposed Development.

[3] PI is a commercial product of OSISoft: https://www.osisoft.com/pi-system/



Graph 3: Example output of the auditing available from turbine SCADA data for another SPR windfarm in 2018. The blue shaded areas show the predicted mitigation (based on weather data) and the red dashed line shows the actual mitigation implemented during each night automatically by the CORE software. Data not available during two periods of site outage 9-29th May and 5th July – 12th August, when turbines were non-operational.

8.5 Monitoring

8.5.1 Rationale and Objective

16. Monitoring would comprise measurement of bat activity and fatality rates, and would be undertaken annually until validation of the initial parameters and any amendments are established in consultation with SNH.

17. The maximum increase to natural mortality due to bat fatalities which is considered unlikely to have a significant effect on bat populations, and therefore deemed 'incidental', is considered to be 2 bat fatalities per turbine per year. This is based on fatality thresholds applied at German windfarm sites (irrespective of species present) and is achievable without excessive losses in power production (yield) [45]. Due to the limited data available on bat populations and bat ecology in Scotland it is not possible to predict exact impacts on bat populations, therefore applying a fatality value from within a European context is the best currently available method of establishing a threshold.

18. The basis of *"incidental"* levels of bat mortality arising from windfarm operation being criminal was considered in RWE vs Eaton 2012 in England, which ruled that a threshold of bat fatalities must exist enable legitimate activities to take place.

19. **The objective of the monitoring is to provide a robust estimate of the total number of bat fatalities, which will be used to determine whether the mitigation is effective**. There is no specific objective to determine the specific weather conditions under which a fatality may have occurred, since the hypothesis at Year 1 is that the mitigation would be effective. As such the proposed sampling approach varies from that suggested in Appendix 4 of the guidance[2].

[4] Behr, O. (2015). 'Bat-friendly' operation of wind turbines – the current status of knowledge and planning procedures in Germany. Presentation at Wind Power and Wildlife Symposium, Stirling University.
[5] http://www.windbat.techfak.fau.de/tools/index_en.shtml ProBat tool used in Germany to help select curtailment parameters to achieve <2 fatalities / turbine / year

8.5.2 Overview

20. The survey methodology will comprise static bat detectors at 6 randomly selected wind turbines during July – September inclusive which is when most fatalities are found to occur. This represents a precautionary approach in that if bat fatality rates are sufficiently low during this period, they are highly unlikely to be greater at other times of year. Therefore if the mitigation is effective during this period, it will be effective during periods of lower levels of activity. The use of 6 turbines is considered to provide a representative sample (46% of turbines sampled) and is coincident with the number of turbines which can reliably be searched by a dog team in a single day.

21. Microphones will be mounted 2 m height below the turbine nacelle and positioned horizontally facing away from turbine towers.

22. Carcass searching will be undertaken within a 50 m radius at the same 6 turbines every 2 weeks from 1st July until end of September i.e. 7 searches in total. An example search schedule, which was used for the worked example below, is shown in Table 1. The search schedule will be adapted, should turbines be non-operational or not revolving during the night prior to the scheduled search.

23. A worked example of the expected parameter estimation and resulting precision of estimates is described below.

Search Date	T1	T2	T3	T4	T5	T6
1st July	1	1	1	1	1	1
15th July	1	1	1	1	1	1
29th July	1	1	1	1	1	1
13th August	1	1	1	1	1	1
27th August	1	1	1	1	1	1
10th September	1	1	1	1	1	1
24th September	1	1	1	1	1	1

Table 1: Example search schedule using 14 day search interval

8.5.3 Estimates and Precision

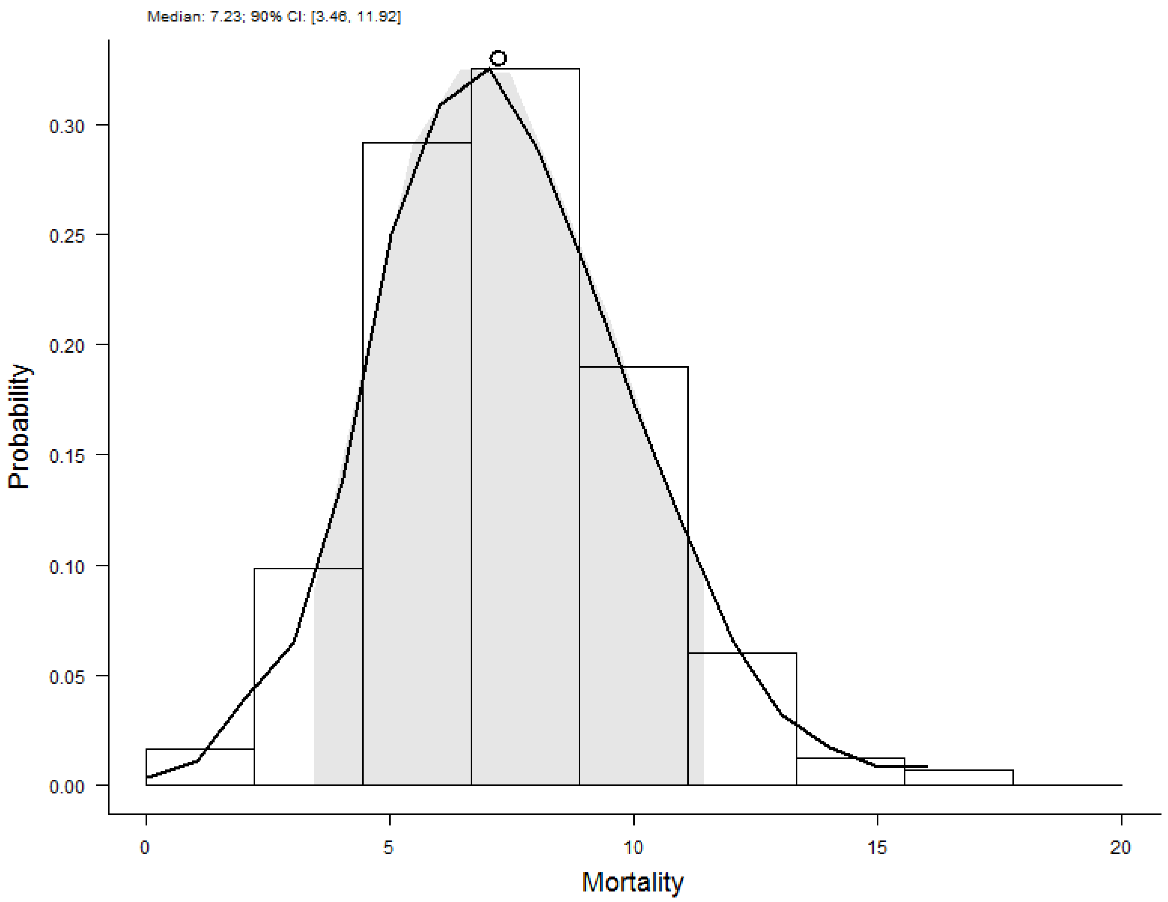
24. All sampling methods are a pragmatic compromise, and an acceptable threshold for the precision of the estimates must be made. The precision of fatality estimates is based on four key factors: carcass persistence rate; observer efficiency rate; search interval and proportion of area searched.

25. The median carcass persistence rate for bat carcasses at other SPR sites from n=32 trials has been estimated at 21.54 days[6]. This may vary at the proposed Development, and as such will be estimated across the monitoring period by placing n=5 bat carcasses distributed randomly below the n=6 turbines to be searched during each survey (i.e. n=30 bat carcasses trials in total). Each carcass will also be paired with a motion activated camera-trap, which will provide the exact timing as to when a carcass is removed. The carcasses will then be checked manually on the following survey and left in-situ if remains are still visible for a maximum of 4 weeks (i.e. 2 survey periods) then retrieved.

26. The search methodology will aim to achieve an observer efficiency rate of >80 % (i.e. 80 % of carcasses which are present are detected) and will calculate this using integrated trials of the n=30 carcasses placed to determine carcass persistence. Previous work at SPR sites using trained dog teams (and for the DEFRA study[1]) has demonstrated that an observer efficiency rate of >0.81 is achievable. It is assumed that 100 % of the area under the turbines will be searched since there are no ground conditions at the proposed Development which would restrict access, although this will be checked during surveys. Based on these parameters and a 14 day search interval (i.e. every 2 weeks), a median estimate of 54.5 % (95 % CI 42.3-66 %)[7] of carcasses which exist will be detected.

[6] Calculated using GenEst "Carcass persistence" package, lognormal model
[7] Calculated using GenEst "Detection Probability" package

27. Based on the above parameters, if n=5 carcasses were found the adjusted median total fatality estimate would be 7.23, with a 90 % confidence interval between 5 and 11.92[8] (Graph 4).



Graph 4: Probability distribution of estimates of true fatality rate based on the monitoring design described and a scenario where 5 carcasses are found.

28. Therefore, in order to be 90 % confident that the true fatality rate is less than 2 bats per turbine per year (i.e. n=12 fatalities), 5 or fewer bat carcasses must be detected within the total search area using the survey methodology outlined above.

8.5.4 Analysis

29. Detailed analysis of the results will be undertaken using the USGS developed Generalised Mortality Estimator software[9], which combines different accepted methods of calculating fatalities into a single tool and allows different models to be fitted to datasets depending on their distribution. It also combines the calculation of different sources of error around each parameter into an estimate of uncertainty around the final estimate.

8.5.5 Change Management

30. Following each annual monitoring period, if the number of bat fatalities is less than 2 bats per turbine per year, the operator shall be entitled to propose amendments to the curtailment parameters. If the number of bat fatalities is greater than 2 bats per turbine per year, the operator shall be obligated to propose amendments to the mitigation. Any changes proposed will be consulted on with SNH, and implemented the following year with repeated monitoring using the methods described above unless otherwise varied (e.g. to investigate condition in which fatalities are occurring).

[8] Calculated using GenEst “Mortality Estimation” package
[9] https://www.usgs.gov/software/genest-a-generalized-estimator-mortality

8.6 References

Behr, O. (2015) *‘Bat-friendly’ operation of wind turbines – the current status of knowledge and planning procedures in Germany*. Presentation at Wind Power and Wildlife Symposium, Stirling University

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Windbat 2016, Federal Ministry for Economic Affairs and Energy Germany, accessed 8th May 2019, <www.windbat.techfak.fau.de/tools/index_en.shtml>