Reducing uncertainty in IA with continuous monitoring & adaptative management

Sandra Rodrigues[1*], Joana Ribeiro[1], Luís Rosa[1], Helena Coelho[1] & Miguel Mascarenhas[1]

[1] Bioinsight – Ambiente e biodiversidade, Lda., Portugal.

[*] Corresponding author: sandra.r@bioinsight.pt

INTRODUCTION

There is still much uncertainty associated with environmental impact assessment (IA), particularly when it comes to determining collision risk at wind farms (WF). Collision risk models (CRM) allow, to some extent, reduce uncertainty through quantification of the impact by predicting fatality due to collision with WF, instead of a qualitative assessment of the impacts.

Currently, traditional approaches to IA focuses on qualitative assessments from specialists of monitoring data. For WFs, a prediction on the expected number collisions is a crucial aspect. High fatalities can negatively impact populations (May *et al.,* 2019), therefore, mitigation measures are usually triggered in response to such results from monitoring surveys of IA studies. However, the mitigation hierarchy (Jacob *et al.* 2016) tells us we should avoid before mitigating. This means preventing before reacting. To do so, it is crucial to anticipate the negative impacts so that proactive measures can be implemented to prevent impacts whenever possible. Collision risk models (CRM) aim to provide a prediction of the number of collisions that may occur in a WF (Masden & Cook, 2016). Consequently, they can be useful as an aid this anticipation and in the decision-making process, prior to the construction phase, at licencing and mitigation level (Normandeau, 2012). Additionally, by anticipating a prediction on fatalities, it may help reduce uncertainty associated with the expected impacts of a WF. However, doubts in whether CRM can correctly predict fatalities are still an issue and not yet fully validated (Masden & Cook, 2016).

Therefore, our main goal was to understand if CRM can provide useful information for IA, thus reducing uncertainty typically associated to IA. To do so, we had two main questions to answer using a case study. **Question 1:** would we have made different recommendations along the IA process had we used CRM? We compared results and recommendations we adopted while using the "traditional approach" (i.e., with no CRM) and an approach where we would hypothesise recommendations based on results if a CRM was used (i.e., a "CRM approach"). Then, our **question 2:** Can CRM replace expensive carcass surveys and how reliable are the results? Again, we compared the "traditional approach", in this case the fatality estimates from carcass searches with the "CRM approach" given by the number of precited collisions of CRM.

METHODOLOGY

To address our goals, we selected the "Serra dos Candeeiros" wind farm as case study. It is located in Portugal and has the particularity of being situated in a category II protected area within the "Serras de Aire e Candeeiros" National Park, and partially coincident with a Natura 2000 site (PTCON0015). As a result, this WF is subject to monitoring until decommissioning which results in a long-term data series of monitoring data (over 10 years). In terms of project timeline, a general monitoring programme of birds initiated in 2003, during pre-construction phase; operation phase started in 2005, as did mortality monitoring. High levels of

Kestrel (*Falco tinnunculus*) mortality led to an adaptation of the monitoring program to focus on this species in 2008. A mitigation and compensation plan for Kestrels was initiated in 2013. Mortality levels slightly decreased which led to the review of the mitigation program in 2018. Additionally, the WF area suffered several external factors, such as wildfires that occurred nearby at specific years (see Figure 3), as well as shrubs clearance to create fuel management strips next to the wind turbines as a wildfire prevention measures.

In terms of CRM, the Band model (Band, 2012) was used along with modifications developed by Masden (2015) because it allows to account for uncertainty associated to the input parameters and thus, reflecting this uncertainty in the results. However, the Band's 2012 version was developed for offshore sites. Offshore and onshore data differ mainly in the way bird data is collected. We modified the CRM so that we could use onshore data as input but still benefit from not only all the updates introduced in the Band's 2012 version, but also benefit from the Masden's version updates. We bypassed the first steps of the Band/Masden approach and used calculations described by the Band's 2007 version (Band *et al*., 2007; see Figure 1) which supported onshore data.

To answer to question 2 defined in our goals, we compared the number of predicted collisions from this adapted CRM approach with fatality estimates obtained from onsite carcass searches. The fatality estimator used was GenEst (v1.4.0.1; Dalthrop *et al.,* 2019).

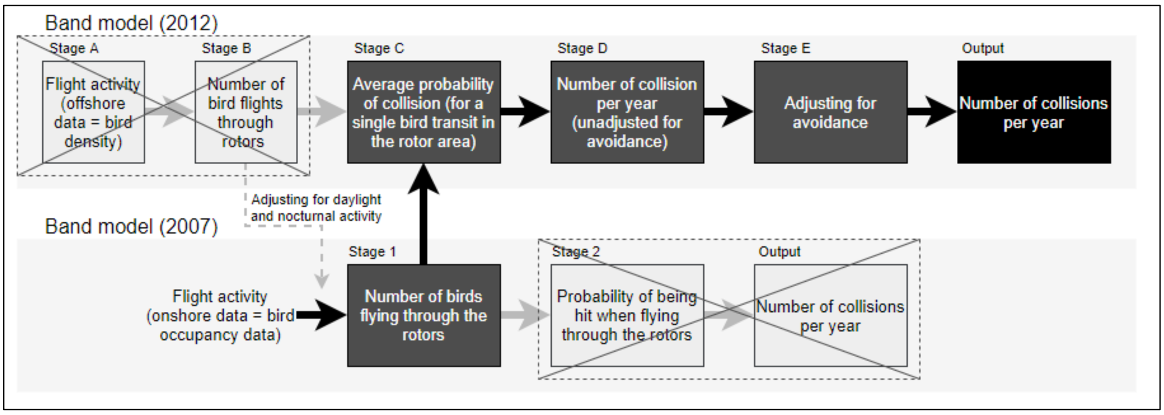

Figure 1 - Calculation steps used to estimate the number of collisions per year. The two version of the Band model were used in a merged approach: the first steps of the 2007 version were used to allow using data from onshore WF; the later stages and calculations steps of the 2012 version were used to allow making use of relevant aspects of the newer and updated version of the model.

Additionally, we also tested a "spatial" approach of the CRM model to understand if it could identify critical areas in terms of expected collisions in the WF area and provide useful information for IA. Since Band (2012) suggested that collision risk is directly proportional to the bird flight at rotor risk height, we followed his suggestion and we adapted our approach (Figure 2) to calculate the collision risk per area. We collected data from vantage points in the format of georeferenced routes (instead of just bird counts for the overall area of the WF) and overlaid it with a 500 x 500 m grid. The flight activity per grid was obtained by summing data associated to the proportion of the routes that fell in each grid cell.

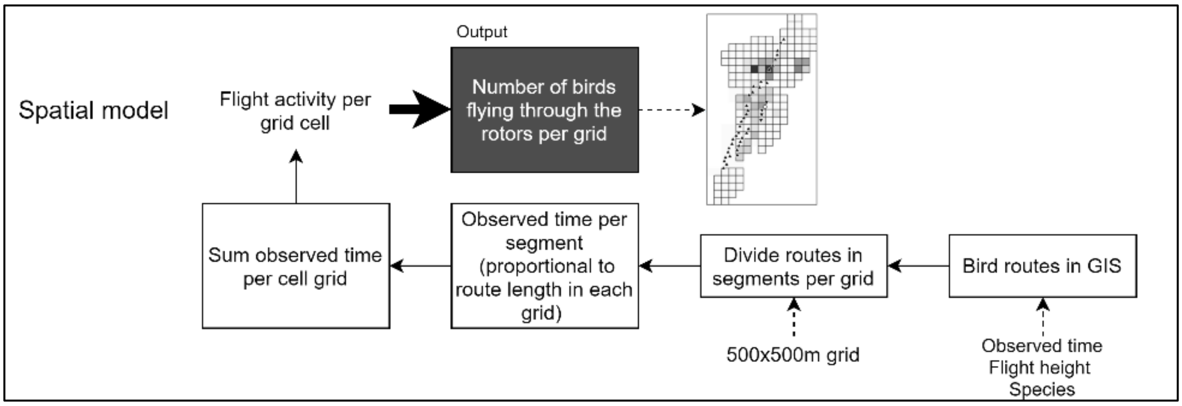

Figure 2 - Band model adaptation for "spatial" approach. To calculate collision risk per area, first we georeferenced bird routes in a geographic information system, adding information about their duration in seconds and flight height. We split each route using a 500x500m grid to calculate route segments length per cell to proportionally split their duration. Finally, we summed all routes seconds in each cell. This information corresponded to flight activity per cell.

FINDINGS

Question 1: Would we have made different recommendations had we used CRM?

We started by analysing the decisions made during the pre-construction phase: in the "traditional approach" (i.e., with no CRM) impacts such as displacement, habitat loss and mortality due to collision were predicted. Although birds of prey and soaring birds were flagged as more susceptible, no target species were identified because the data collected during pre-construction did not raised concerns in terms of prediction on collisions. But this analysis was only qualitative, based on expert's opinion of flight activity observed in the area. No model was used to relate the flight activity and collisions. However, if a "CRM approach" had been adopted at this stage, CRM would have predicted mortality of Kestrels and these species would have been identified as a target species right from the start of the IA.

Then, we looked at decisions made in IA during the operation phase. High levels of Kestrel mortality were unexpected because they were not predicted during pre-construction phase. The mortality that was occurring led to adjustments in the monitoring plan to target Kestrels so that mitigation measures could be designed. If CRM had been used, these high levels of mortality would not have been unexpected and mitigation measures may have been suggested right from the start of the operation phase, rather than a few years later. Therefore, mitigation was a consequence of the observed impacts in the "traditional approach". On the contrary, the "CRM approach" would have predicted impacts on Kestrel and these impacts and mitigation would have been anticipated.

Results from using the "spatial" approach with CRM with the purpose of identifying critical areas in the WF was particularly interesting as it is usually not included in traditional IA reports. The resulting risk maps systematically indicated that the middle section of the WF had higher risk of collision (Figure 3). The relevancy of these results is that in the "traditional approach", mitigation measures were applied at turbine level (i.e., to specific turbines with higher fatality). However, fatality levels in each turbine changed from year to year. The "spatial" CRM approach could have predicted broader areas where the risk is higher and identify potentially problematic areas. This can provide a general idea where mitigation would be most effective in a larger scale, rather than at turbine level scale.

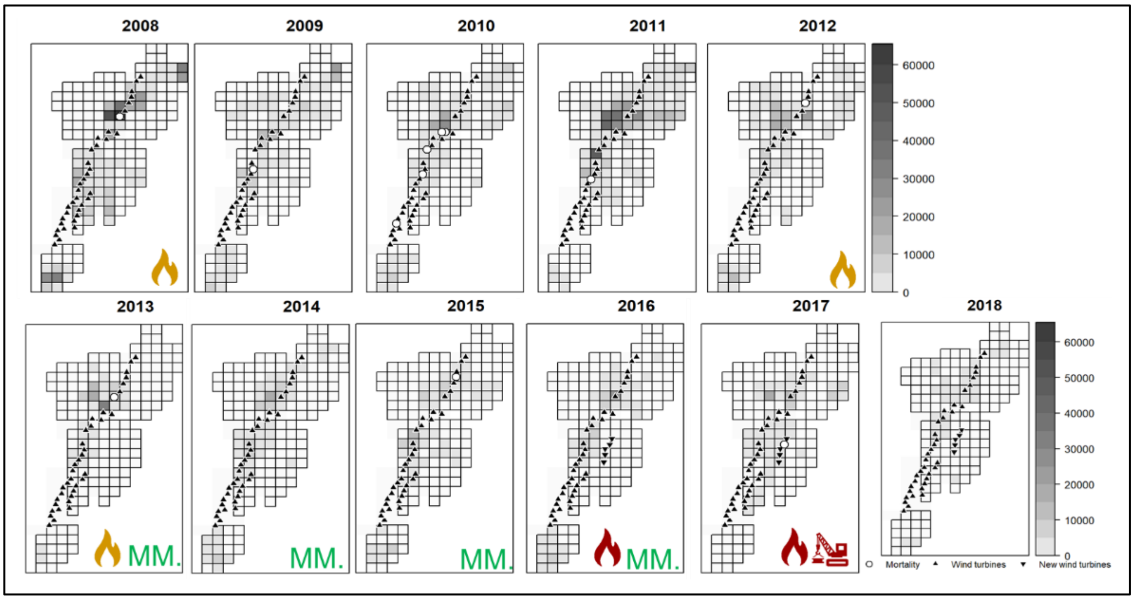

*Figure 3 – Collision risk maps obtained from using a "spatial" collision risk model from Kestrels (*Falco tinnunucus*) from 2008 to 2018. Legend: Shades of grey for each cell grid indicate collision risk: darker shades indicate higher risk; black triangles indicate position of turbines of the WF; circles indicate collision events; orange flame – wildfires around 1 to 10 km the WF; red flame – wildfires less than 1 km from the WF; MM – mitigation measures; red tractor – represents shrubs clearance activities next to the turbines to create fuel management strips as a wildfire prevention measure.*

Question 2: Can CRM replace expensive carcass surveys and how reliable are the results?

In the "traditional approach", monitoring programs include field work to search for carcasses to estimate fatality. Field surveys usually require great effort and regular visits to the WF to detect carcasses and determine correcting factors, such as carcass removal rates and detectability of carcasses. If CRM can predict the number of collisions similar to the expected fatality, theoretically, carcass monitoring could be replaced by bird activity monitoring to feed collision models.

In our case study, we compared the estimated number of fatalities predicted from carcass searches using GenEst with the number of collisions per year predicted by the CRM (Figure 4). We used a Wilcoxon rank test to test if there was a statistical difference, after testing that our data was not parametric. Results indicate that there were no significant differences between predicted collisions and expected fatalities (p-value > 0.05). Additionally, since our goal is to analyse results in terms of IA context, i.e., CRM accuracy is analysed in terms of how different our recommendations would be if we were analysing the data using CRM rather than the data from typical carcass searches.

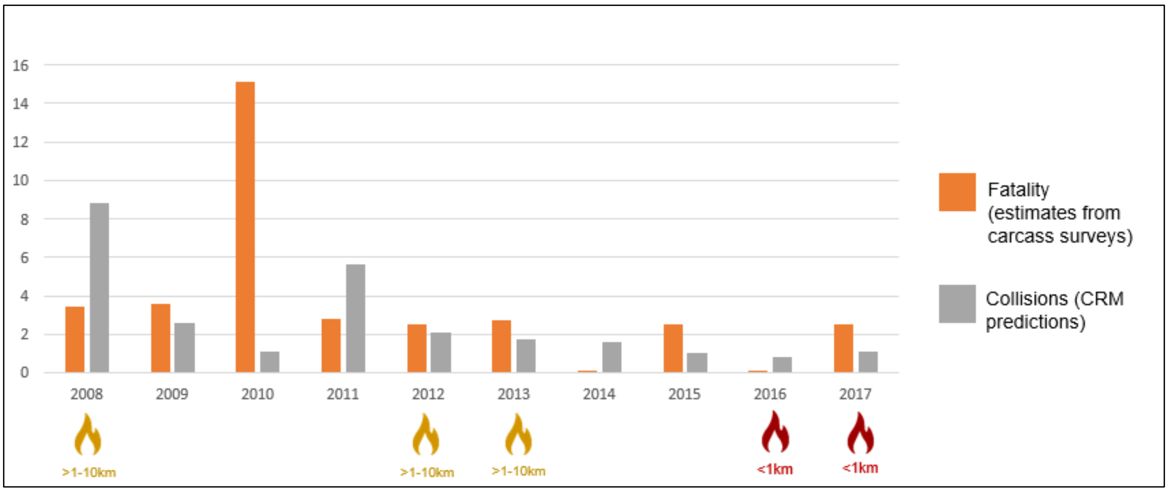

Figure 4 - Estimated number of fatalities from carcass searches using GenEst estimator (orange bars) and number of predicted collisions using CRM (grey bars) (additional information: orange flame – wildfires from 1 to 10 km from WF; red flame – wildfires less than 1 km from the WF).

Despite the fact that no significant statistical differences were found between fatalities and collisions, there is a particular year in need of discussion. During our time series, the highest fatality of Kestrels was recorded in 2010. Yet, bird activity in that year was actually lower than previous years which resulted in lower collision estimates. This indicates that CRM cannot predict collisions which may result from extreme events. The "spatial" CRM approach was also unable to predict high risk of collision in 2010. Nevertheless, results revealed that CRM was able to predict 67% of the carcasses locations, i.e., carcasses were found within areas identified in the risk maps as high risk areas (Figure 3).

In general, our findings suggest that although the "traditional approach" with carcass surveys provides better mortality estimates, including mortality caused by extreme events of mortality. However, obtaining carcass searches data is expensive compared to obtaining flight activity data to feed CRM models. Nonetheless, the "CRM approach" can predict a number of collisions with a satisfactory range of accuracy (in terms of an IA context) and it would have not triggered different recommendations from the "traditional approach". It is relevant to point out that CRM fails to predict extreme events of mortality. However, these events are isolated events in time and do not trigger different actions in terms of IA.

FINAL CONSIDERATIONS

Based on our case study, we believe that collision risk models can be used to reduce uncertainty in IA because it provides quantitative data rather than qualitative information based mainly on how experts analyse monitoring data. Therefore, we conclude that CRM use in IA can provide useful and relevant information. Our findings indicate that CRM can predict the number of collisions in a WF with a satisfactory accuracy level, considering that the difference between the CRM predictions and the estimated fatality obtained from carcass searches would not have triggered different actions and recommendations in the IA process. Additionally, using a CRM would have enabled to better anticipate the impacts during pre-construction phase as well as indicating the expected level of fatality per year during operation phase. Therefore, CRM should be used both for pre-construction and operation phase. Although CRM can predict collisions within a satisfactory accuracy level considering an IA context, it failed to account for unusual high levels of fatality caused by unknown events. Consequently, CRM should not be used to replace carcass searches, but rather used as a complementary analysis. Therefore, the need for continuous monitoring remains. Finally, a “spatial” approach is extremely useful in IA because it can identify critical areas in a WF at a broader scale rather than turbine level.

Overall, CRM can reduce uncertainty and provide useful information for IA. It adds value to the process, making it clearer and less subjective. Additionally, recommendations can be made in advance, more proactively than when only using monitoring results which trigger reactive actions and recommendations. Nevertheless, there is still much uncertainty and CRM does not eliminate the need of monitoring programs. Rather, it adds information and helps providing more meaningful and supported recommendations.

REFERENCES

Band, W., Madders, M., Whitfield, D.P. (2007). In: De Lucas, M., Janss, G.F.E., Ferrer, M. (Eds.), Developing Field and Analytical Methods to Assess Avian Collision Risk at Wind Farms. Quercus, Madrid.

Band, B. (2012). Using a Collision Risk Model to Assess Bird Collision Risks for Offshore. SOSS Report. The Crown Estate.

Behr, O., Brinkmann, R., Hochradel, K., Mages, J., Korner-Nievergelt, F., Niermann, I., Reich, M., Simon, R., Weber, N., & Nagy, M. (2017). Mitigating Bat Mortality with Turbine-Specific Curtailment Algorithms: A Model Based Approach. *Wind Energy and Wildlife Interactions*, 135–160. https://doi.org/10.1007/978-3-319-51272-3_8

Dalthorp, D., Simonis, J., Madsen, M., Huso, M., Rabie, P., Mintz, J., Wolpert, R., Studyvin, J., Korner-Nievergelt, F., (2019). GenEst: Generalized Mortality Estimator. R package version 1.4.0.1 (2019-11-20).

Jacob, C., Pioch, S., & Thorin, S. (2016). The effectiveness of the mitigation hierarchy in environmental impact studies on marine ecosystems: A case study in France. Environmental Impact Assessment Review, 60, 83-98.

Masden, E. (2015). Developing an avian collision risk model to incorporate variability and uncertainty. Scottish Marine and Freshwater Science Vol 6 No 14. Edinburgh: Scottish Government, 43 pp.

Masden, E. A., Cook, A.S.C.P (2016). Avian collision risk models for wind energy impact assessment. *Environmental Impact Assessment* Review 56:43-49. https://doi.org/10.1016/j.eiar.2015.09.001

May, R., Masden, E., Bennet, F., & Perron, M. (2019). Considerations for upscaling individual effects of wind energy development towards population-level impacts on wildlife. Journal of *Environmental Management*, 230, 84–93. https://doi.org/10.1016/j.jenvman.2018.09.062

Normandeau Associates, Inc. (2012). A Habitat-based Wind-Wildlife Collision Model with Application to the Upper Great Plains Region. Final Report for the U.S. Department of Energy. Gainesville, Florida. 98 pp.