Review and update of collision risk models for predicting potential collisions of birds with turbine blades

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Presentation Outline

1. General background
2. Review of Collision Risk Models
3. Stakeholder interviews
4. Developing an update to the Band Collision Risk Model

Avian Collision Risk Models

- CRM used to predict the likely number of bird collisions with a wind turbine/farm
- Bird and turbine inputs (no uncertainty/variation)
- Core usually probability of collision from a single transit
- Based on probability of a turbine blade occupying same space as bird during the time that bird takes to pass through rotor
- One transit to many, using survey data
- Add element of bird behaviour i.e. avoidance
- Output is usually a single estimated number of collisions

BTO
Looking out for birds

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Variability: variation due to natural processes

Uncertainty: our ability to understand and measure the environment

CRM Review

- Reviewed literature on avian CRM
- Descriptive comparison of 10 models

CRM Review

Model name and reference	Based on…	Number of turbines	Tower included	Wind speed/direction included	Oblique angles of approach	Individual or population	Onshore or offshore example	Stochastic or deterministic	Model output
Band (Band 2000; Band 2012)	-	Multiple	N	N	N	Population	Offshore	D	# birds colliding
Tucker (1996)	-	Single	N	N	N	Individual	-	D	Probability of collision
Biosis (Smales *et al.* 2013)	-	Multiple	Y	N	Y	Population	Onshore	D	# birds colliding
Podolsky (Podolsky 2008)	-	Multiple	Y	N	Y	Individual	Onshore	D	Probability of collision
McAdam (McAdam 2005)	Band	Single	N	Speed & direction	Y	Individual	Offshore	S	Probability of collision
Desholm (Desholm & Kahlert 2007)	-	Multiple	N	Direction	N	Population	Offshore	S	# birds colliding
Eichhorn (Eichhorn *et al.* 2012)	Band	Single	N	N	N	Individual	Onshore	S	Mortality rate
Holmstrom (Holmstrom *et al.* 2011)	Tucker	Single	N	Speed & direction	Y	Individual	-	D	Probability of collision
Bolker (Bolker, Hatch & Zara 2014)	-	Multiple	N	N	Y	Individual	Onshore	D	Probability of collision
USFWS (U.S. Fish and Wildlife Service 2013)	-	Multiple	Not specified	N	N	Population	Onshore	S	Number of fatalities

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CRM Review summary

- No single model included everything
- Core models seemed similar
- Differences around the edges
- What was wanted from a [new/updated] model?

Interviews

- 20 people from a range of stakeholders in UK
- Questions on CRM and variability and uncertainty
  - If you could, how would you improve collision risk modelling?
  - Would including variability and uncertainty in collision risk models benefit the consenting process and discussions with regulators?
- Majority use most recent Band model
- Some of the responses…

Interview responses

- There is a fixation on single numbers
- Stop presenting single numbers as black and white and also provide context
- Decision makers have to be confident that they are making the right decisions so they need to have an understanding of uncertainty around the single numbers
- Present a covering/summary sheet with input data values to ensure parameters are clearly set out and defined
- Use R code rather than excel to make modelling process more reproducible
- Factor uncertainty into estimates

Collision Risk Model Update

AIM

To develop a simulation update to the Band CRM incorporating variability and uncertainty

REASONING

- Impact assessment should include both magnitude of event and likelihood of occurrence
- Has been included in other CRMs
- Interviews suggested there was a need
- Sensitivity analyses showed the Band model output is sensitive to changes in input values (Chamberlain et al., 2006)

Model Update - Overview

- Monte Carlo simulation version of Band model
- Requires distribution data input i.e. mean and sd
- Includes wind speed data
  - Link with rotor speed and pitch
- Produces distribution data output
- Uses R not Excel so reproducible
- Outputs figures and tables as well as input data
- Output can feed into population models/PVA

Methods

- Monte Carlo simulation
- Computational technique that uses random sampling
- Used to obtain values for uncertain or variable input parameters
- For each set of random samples, a collision estimate is calculated
- If the simulation is run for 100 iterations, 100 sets of random input parameters will be sampled and 100 collision risk estimates calculated
- Produces distributions of possible collision estimates instead of a single value

Input data required

- The same
  - Bird and turbine data as current Band model
- But different
  - Requires mean and standard deviation rather than single value
- And in addition
  - Wind speed data
  - Relationship between wind speed and rotor speed and pitch

Wind speed (m/s)	Rotor Speed	Pitch
0	0	90
1	0	90
2	0	90
3	6	0
4	6	0
5	6	2
…	…	…

Running the model

- Semi-automated
- Loops through multiple species
- Loop through multiple turbine designs
- Results will be saved automatically to the location specified by the user

Model outputs

- Tables
  1. Overall summary table of collisions by species, turbine and model option.

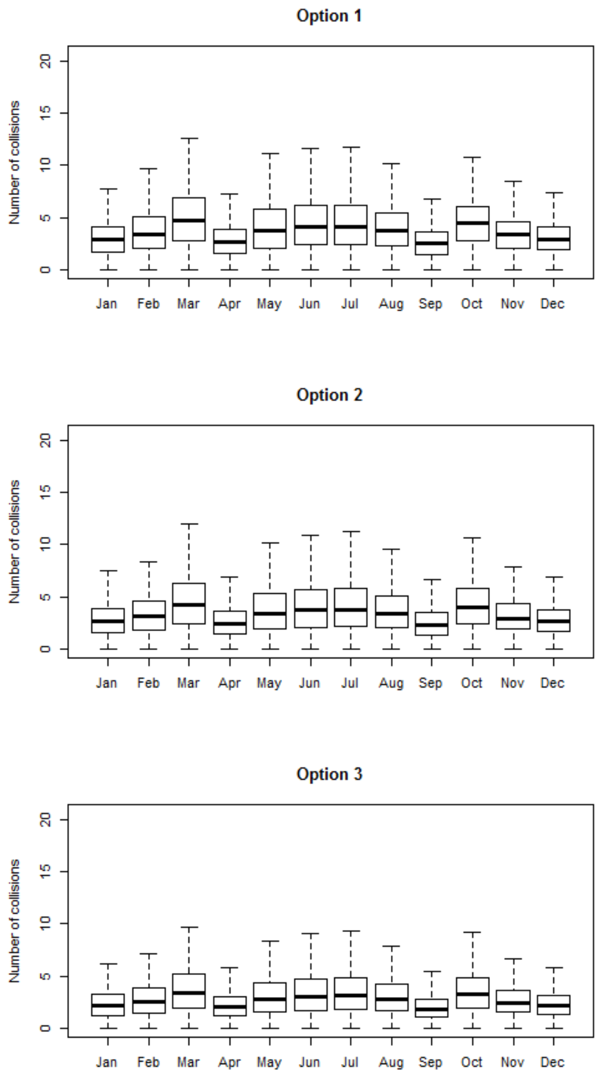
Species	Turbine	Option	Mean	SD	Median	IQR
Black_legged_Kittiwake	6	1	45.64559	12.54484	45.12069	16.54937
Black_legged_Kittiwake	6	2	42.42928	14.56218	40.30321	18.6712
Black_legged_Kittiwake	6	3	35.41312	13.12714	33.02787	16.4662

  2. Monthly summaries of collisions. Separate tables are produced according to species, turbine and model option

Month	Mean	SD	Median	IQR
Jan	3.080382	1.753642	2.970413	2.441757
Feb	3.590156	2.012736	3.439408	3.043374
Mar	4.884338	2.76244	4.716011	4.134139
Apr	2.89007	1.763726	2.648057	2.297968
May	4.255352	2.845274	3.771635	3.664073
Jun	4.458946	2.63927	4.172458	3.708436

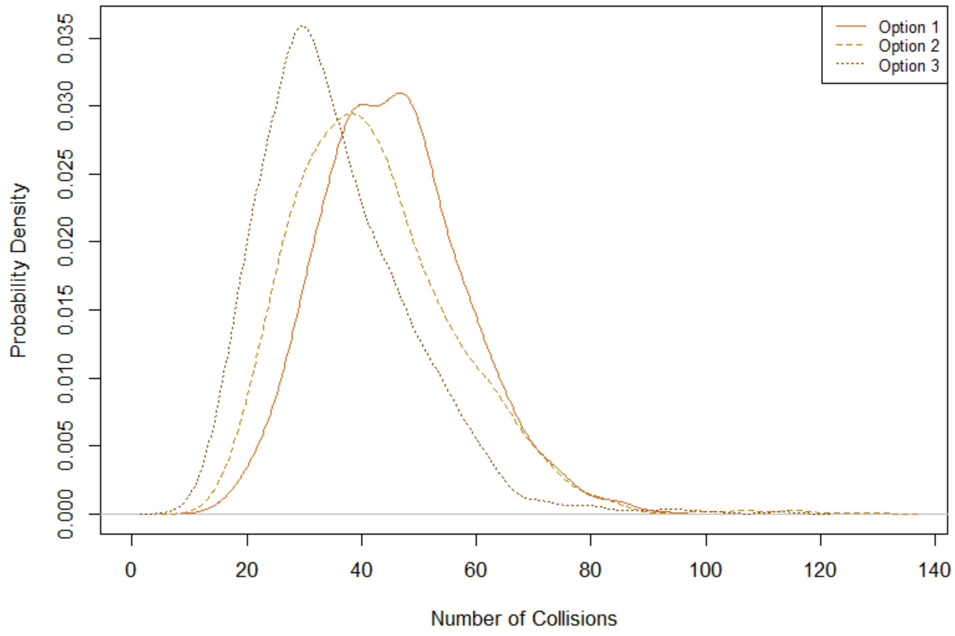
Model outputs

- Figures
  1. Boxplots of monthly collisions



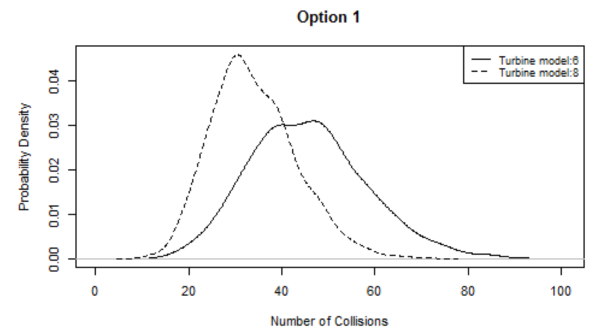
Model outputs

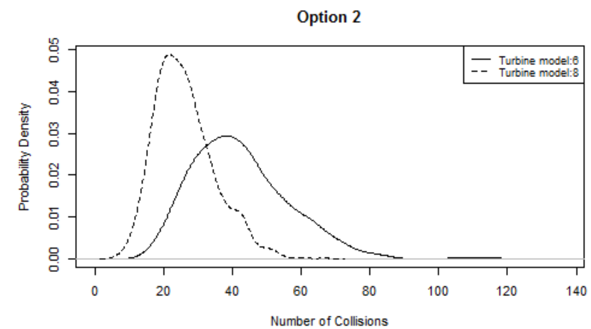
- Figures
  1. Boxplots of monthly collisions
  2. Probability density plots of numbers of collisions

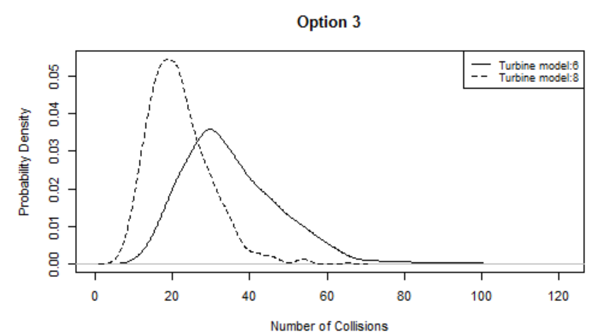


Model outputs

- Figures
  1. Boxplots of monthly collisions
  2. Probability density plots of numbers of collisions
  3. If ≥ 2 turbine models included…







Looking out for birds

Application to subsea turbines

- An adaptation of Band model being considered for marine tidal turbines and interactions with diving birds
- Lack of knowledge of underwater environment
- Inclusion of uncertainty and variability equally relevant subsea
- Could benefit from lessons learnt from wind

Conclusions

- Produced Monte Carlo simulation of Band model
- Allows for inclusion of variability and uncertainty in parameters
- Similar principles can be used for subsea calculations
- Model description and a worked example will be available on NERC website
- R code will also be available