Understanding avian collision rate modelling and application at the population level

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Bureau Waardenburg (Buwa)
Introduction to talk

BTO and Bureau Waardenburg

Birds and wind energy
Counting collisions
Why collision rate modelling

Overview of different models
Band model
Sensitivities and knowledge gaps

Results in the population context

How are outputs used by decision makers?
British Trust for Ornithology

• Independent & **IMPARTIAL** research organisation
• Provide advice to regulators & governmental advisors
• Also do work for Industry
• Key projects
  – Strategic Ornithological Support Services (SOSS)
  – Dogger Bank EIA
  – Seabird tagging to understand movements in & around offshore wind farms
  – Key reviews of survey methodology, seabird flight height & avoidance behaviour, collision risk modelling methodology, post-consent monitoring
• Ensure that decisions are based on the “Best available evidence”
Bureau Waardenburg

Mark Collier

• Ecological research and consultancy, founded in 1979.
• 75 staff, specialising in marine and aquatic ecology, nature and landscape, bird ecology.
• National and international projects – advise Governments, regulators and industry.
• Independent and objective approach. Creative and innovative solutions with a high level of practicality.

Wind energy and birds since 1992.

• Effect studies, EIAs, AAs, advice, monitoring, research, planning research and monitoring programmes, etc...
• Radar systems (mobile and automated)
• Remote technologies
• First Dutch offshore wind farms, gas platform 75 km from the shore, CRM for NL and UK round 3 sites, onshore wind.

Combining practical knowledge with theoretical techniques.
Introduction to BTO & Bureau Waardenburg
Introduction to BTO & Bureau Waardenburg

SOSS Steering Group

We would like to thank all SOSS steering group members for their valuable contributions to SOSS work. The steering group was made up of representatives of regulatory, advisory bodies, and offshore wind farm developers, as well as the SOSS Secretariat. Some offshore wind farm developers chose to nominate consultants to attend in their place. Steering group members guided the identification and prioritisation of SOSS work, and advised on the development of scopes of work and project outputs.

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Role</th>
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<tbody>
<tr>
<td>BTO</td>
<td>SOSS Secretariat partner</td>
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<tr>
<td>The Crown Estate</td>
<td>SOSS Secretariat partner</td>
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<tr>
<td>Bureau Waardenburg</td>
<td>SOSS Secretariat partner</td>
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IMCC3 • 14-18 August, 2014 • Glasgow, Scotland

International Marine Conservation Congress
Birds and wind energy

**Displacement** of birds to other areas

**Habitat loss**
- Mostly limited to specific locations/species.
- On land and relatively small area (footprint of turbines and related infrastructure).

**Disturbance** of foraging/resting birds
- Mostly limited to specific locations/species.
- e.g. Bewick's swans showed preference to forage further from turbines early in season then moved closer to turbines (Fijn et al. 2012).
- Increasing importance with increase in wind farms (cumulative effects).


Top photo: Zeeland Ait/Bureau Waardenburg
Birds and wind energy

Displacement of birds to other areas

Barrier effects (disturbance of flight paths / effective habitat loss)

- Mostly limited to specific locations/species (e.g. breeding colony).
- e.g. migrating eiders travelled only 500m further during their 1400km migration (Masden et al. 2009).
- Increasing importance with increase in wind farms (cumulative effects).

May influence survival indirectly
Increasing importance with more wind farms - cumulative effects

Birds and wind energy

**Collisions** of flying birds
Direct mortality – attracted most attention

Current estimates of 0.05 - 30 (up to 60) collisions per turbine per year, fewer offshore (Krijgsfeld et al. 2009).

<table>
<thead>
<tr>
<th>Altamont Pass, Ca. = 5,400 turbines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated collisions annually:</td>
</tr>
<tr>
<td>&gt;2,700 – 11,500 birds</td>
</tr>
<tr>
<td>&gt;1,100 –  2,300 raptors</td>
</tr>
<tr>
<td>(Smallwood &amp; Thelander, 2008)</td>
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</tbody>
</table>

Variation due to: flight intensities, location, time of year or day, species…
Counting collisions

Victim searches

- Daily to weekly searches.
- Corrections needed for search efficiency and predator removal.
- Use of dogs.

+ fulfil monitoring obligations
+ build on knowledge of bird-turbine interactions
+ combined with (radar) studies on flight patterns

- labour intensive (larger wind farms)
- access to location
- not all habitats
- not offshore
- not pre-construction
Counting collisions offshore

Observations - too few collisions!
- one every two weeks to 20 years!
- at night or poor weather

Automatic registration system

Reviewed in Collier et al. (2011 and 2012)

Camera and microphones
Counting collisions offshore

Observations - too few collisions!
- one every two weeks to 20 years!
- at night or poor weather

Automatic registration system
Reviewed in Collier et al. (2011 and 2012)

Camera and microphones

Several systems in development:
WT Bird in use offshore - camera to be tested (Bureau Waardenburg)
DT Bird in use – no detection trigger

Still requires development and validation
For post-construction monitoring

Why collision rate modelling

Number of birds x Collision risk = Number of collisions
Why collision rate modelling

Estimate effects:
• prior to construction to inform planning.
• for inaccessible locations.
• on vulnerable species.

Commonly applied models:
Troost (1, 2 & 3) - Empirical and Theoretical based.
   - Developed for Dutch offshore situation.

Band (SOSS Band) - The standard in many countries.
   - key model for offshore.

Flux Collision Model - Empirical based.
   - Based on collision data, less reliant on avoidance rates.
Collision risk modelling

• 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
## Collision risk modelling

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

- UK Most widely used is Band
- Developed by SNH for use with Islay Onshore wind farm
- Subsequently adapted for offshore environment
- Key Changes
  - Monthly estimates
  - Density rather than count
  - Different options for incorporating % birds at rotor height
Sensitivities

- Avoidance Rate
- Flight Height
- Flight Speed
Avoidance Rate

• Identified by Chamberlain *et al.* (2006) as the key parameter in model
  – 10% change in avoidance rate = >2500 % increase in predicted collisions
• Despite this, evidence base remains weak
• BTO Commissioned by MSS to undertake major review in relation to offshore wind farms
Avoidance Rate

- Can be estimated in two ways
  - Direct measurement (i.e. radar, visual observation etc.)
  - Comparing recorded collisions to number of birds present
- First challenge, define spatial scales
  - Macro
  - Meso
  - Micro
Macro

- Draw on evidence from studies of barrier effects/displacement
- Very species specific
- Gannet strong macro-response
- Gulls unclear evidence of attraction & avoidance
Meso/Micro

- Very little evidence for meso/micro
- Key study OWEZ radar + visual observations
- Draw on onshore studies of collisions
  - Estimated collision rate
  - Estimated flux rate
- 20 sites UK, Europe & US
- Mostly gulls, some terns

Avoidance Rate = 1 – (observed collisions / probability of collision x flux)
Total Avoidance

- Combined meso/micro ~99-99.5% for gulls
- No macro, so total avoidance = 99%
- No evidence base for gannet
- High meso/micro rate for gulls + high macro avoidance suggests total avoidance unlikely to be lower than that for gulls
Flight Heights

- Recent analysis (Masden 2015) shows % birds at risk height AS IMPORTANT as avoidance rate
- Typically estimated from boat surveys
- 3 key problems
  - Estimates reflect height above MEAN SEA-LEVEL, turbines must be >22 m above HIGHEST ASTRONOMIC TIDE
  - Restrictive – cannot assess impact of raising/lowering turbine height
  - No measure of uncertainty – single value for each species
- Also analytical issues
Flight Heights
Flight Heights

Collision risk treated as constant within rotor-swept area

In reality, collision risk is variable

Weighted Mean
\[ P_{\text{Collision}} = 0.056 \]

AUC = 16,427 m$^2$

AUC = 5,475 m$^2$
Flight Heights

• Can combine boat data to produce continuous distributions

• “Extended” or “Option 3” Band model

• On going work to produce similar distributions from Digital Aerial Survey data
Flight Speed

- Largely ignored
- Goes into model twice
  - Estimate of flux rate
  - Estimate of probability of collision
- 2 standard sources
Flight Speed

- Similar sensitivity to avoidance rate/bird density/PCH (Masden 2015)
- Low sample sizes, i.e. Kittiwake
  - 2 radar tracks, 660s
- Need for much better data & understanding of how representative it is
Masden update of Band Model

 Criticisms of Collision Risk Models

 “Stop presenting single numbers as black and white and also provide context”
 “…make modelling process more reproducible”
 “Factor uncertainty into estimates”
Masden update of Band Model

• Runs in R
• Monte Carlo Simulations
• Uses distributional data to estimate uncertainty around input parameters
• Also incorporates wind speed data to explicitly model relationship between wind & rotor speed/pitch
Masden update of Band Model

- Semi-automated
- Produces tables of input parameters & collision estimates
- Boxplot of monthly collision estimates
- Probability plot of collision numbers
Results in the population context

Collision Rate

Modelling

\[
\text{number of collisions} = \frac{\text{number of dead birds}}{100}
\]

Level of mortality needed to bring about a change in the population:

- 1% of natural mortality
- Apply mortality to population models
- Potential Biological Removal (potential harvest)
1% of natural mortality

Originally defined for assessing hunting levels (EU ORNIS Committee). In some countries widely applied for assessing effects of human activity.

Compares mortality to 1% of natural mortality threshold.

• >1% possible effect to be investigated further

Colony in Wadden Sea 38,000 birds

adult survival 91.4% = 8.6% adult mortality

Annual mortality = 3,268 birds

1% annual mortality = 32.68
Population models
Population models

- Data gathered on relevant populations;
  - Numbers
  - Life history parameters
    - Survival
    - Breeding success
    - Populations
    - Proportion of floaters

- Models based on matrix models
Population models

Population models

Effect from CRM

Zero-growth/decline

850 collisions/yr

1,800 collisions/yr

Lesser Black-backed Gull
Potential Biological Removal (PBR)

PBR approach (Dillingham & Fletcher 2008)

Level of sustainable mortality
Assesses recovery potential of population = ability to recover

Developed for small populations (cetaceans)
Requires less detailed population data.

Herring gull;
- CRM 11 wind farms = 585 collisions.
- declining population.
- PBR population can sustain 1,200 /yr.

Cautionary approach treated as near threatened
Legislative context

Will the project **adversely** affect the integrity of the site?

- Link to conservation objectives
- Population of qualifying features must be maintained/restored
- Must ensure that any impacts do not cause populations to decline
Assessing impacts

- Population Viability Analysis (PVA)
  - Can derive a range of metrics
- Potential Biological Removal (PBR)
- Acceptable Biological Removal (ABC)
- Suitability of metrics subject to debate
- Concerns relating to
  - Uncertainty in demographic parameters
  - Uncertainty in impacts
  - Relevance to conservation objectives
Summary

Collisions considered the main effect of wind energy on birds.

Collision rate modelling can assess effects:
- pre-construction
- where victim searches are not feasible i.e. offshore

Field data required to inform models:
- Numbers of birds (fluxes)
- Flight heights
- Avoidance

Estimated number of collisions can be assessed in relation to:
- 1% criterion
- population models
- PBR

Compare in context of population and other pressures
More information

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**Band Model**