Marine Bird Impact Assessment Workshop

11.00-12.45

Collision Risk Modelling Session

Dr Alex Robbins
Marine Ornithology Advisor

20th February 2020
CRM Session Outline

1. Stochastic CRM - SNH

2. Stochastic CRM Worked Example - SNH

3. Research update - MSS

4. Issues and knowledge gaps – SNH/MSS

5. Introduction to breakout session
Stochastic CRM

- Preference to move to using a stochastic version of the Band (2012) method e.g. MacGregor et al. (2018).

- A range of collision figures should be presented based on the confidence around input parameters.

- The outputs from the basic Band model are always presented.

- The extended model is not applied to species except black-legged kittiwake, herring gull, lesser and great black-backed gulls.
### Stochastic CRM – Worked Example

#### Number of Turbines

| Number of Turbines | 72 |

#### Latitude (deg)

| Latitude (deg) | 56.4 |

#### Width (Km)

| Width (Km) | 6.7 |

#### Tidal Offset (m)

| Tidal Offset (m) | 2.9 |

#### Wind Availability (%)

<table>
<thead>
<tr>
<th>Month</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Availability (%)</td>
<td>74.00</td>
<td>71.00</td>
<td>69.00</td>
<td>72.00</td>
<td>78.00</td>
<td>86.00</td>
<td>87.00</td>
<td>88.00</td>
</tr>
</tbody>
</table>

#### Mean Downtime (%)

<table>
<thead>
<tr>
<th>Month</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Downtime (%)</td>
<td>6.30</td>
<td>6.30</td>
<td>6.30</td>
<td>6.30</td>
<td>6.30</td>
<td>6.30</td>
<td>6.30</td>
<td>6.30</td>
</tr>
</tbody>
</table>

#### SD Downtime (%)

<table>
<thead>
<tr>
<th>Month</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD Downtime (%)</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>

#### Tidal Offset to Correct For:

1. Flight heights calculated in relation to mean sea-level; and
2. Turbine dimensions calculated in relation to Highest Astronomical Tide

#### Monthly Turbine Downtime (Means & 95% CIs)

- https://dmpstats.shinyapps.io/avian_stochcrm/
Stochastic CRM – Worked Example

Choose between simulating rotor speed and pitch from probability distributions OR from a relationship with wind speed.

- **Rotation (rpm) & SD of Rotation (r)**
  - Rotation: 8.72
  - SD of Rotation: 0.5

- **Pitch (deg) & SD of Pitch (deg)**
  - Pitch: 10
  - SD of Pitch: 0.1

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Stochastic CRM – Worked Example

Wind farm input parameters:
1. MW per turbine not previously presented.
2. Tidal correction - flight height is MSL and turbine calculations are HAT.
3. Monthly operational values now called wind availability.
4. Downtime and SD not previously presented.
5. Rotational speed now one annual value with SD.
6. Pitch SD not previously presented.
Stochastic CRM – Worked Example

- **Body Length (m)**: 0.39
  - **SD of Body Length (m)**: 0.005

- **Wing Span (m)**: 1.08
  - **SD of Wing Span (m)**: 0.04

- **Flight Speed (m/s)**: 13.1
  - **SD of Flight Speed (m/s)**: 1.5

PDF of Black-legged Kittiwake's body length

- **Body Length (m)**: 0.3802 0.3866 0.3900
- **Wing Span (m)**: 1.0016 1.0530 1.0800
- **Flight Speed (m/s)**: 10.1601 12.0883 13.
Stochastic CRM – Worked Example

Nocturnal Activity
- Mean: 0.033
- Standard Deviation: 0.0045

Basic Avoidance
- Mean: 0.992
- Standard Deviation: 0.007

Extended Avoidance
- Mean: 0.967
- Standard Deviation: 0.027

PDF of Black-legged Kittiwake’s basic avoidance

PDF of Black-legged Kittiwake’s extended avoidance
Stochastic CRM – Worked Example

Proportion at CRH: 0.2
SD of Proportion at CRH: 0.009

Flight Height Distribution

Choose data source:
- Johnson et al (2014)
- Other

Data visualisation
- Bootstrap quantiles
- Bootstrap samples

Proportion of Black-legged Kittiwake flying at 1m height intervals (medians and 95% intervals of bootstrap data) - Default Data

Source: Johnson et al (2014)
Choose how to specify the distribution of monthly bird densities

- Truncated Normal
- Distribution reference points
- Distribution samples

Provide the means and standard deviations of monthly densities, assuming Truncated Normals bounded at 0

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean birds/km²</strong></td>
<td>0.20</td>
<td>0.05</td>
<td>0.57</td>
<td>0.61</td>
<td>0.84</td>
<td>2.00</td>
<td>2.68</td>
<td>0.49</td>
<td>1.46</td>
<td>1.59</td>
<td>0.62</td>
<td>0.35</td>
</tr>
<tr>
<td><strong>SD of birds/km²</strong></td>
<td>0.00</td>
<td>0.07</td>
<td>0.60</td>
<td>0.42</td>
<td>0.48</td>
<td>1.38</td>
<td>2.83</td>
<td>0.28</td>
<td>3.30</td>
<td>0.04</td>
<td>0.00</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Line graph: Black legged Kittiwake (Median and 95% CI)
Stochastic CRM – Worked Example

Bird Input parameters:
1. How to calculate SD for monthly density estimates (between years, transects)?
2. Nocturnal activity scores…
3. Currently no capacity to calculate species specific seasons within shiny app
## Stochastic CRM – Avoidance Rates

<table>
<thead>
<tr>
<th>Species</th>
<th>Band version</th>
<th>Previous SNCB advice(^1)</th>
<th>Band (2012) spreadsheet(^2)</th>
<th>MacGregor et al. 2018 sCRM tool (mean ±SD)(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern gannet</td>
<td>Basic</td>
<td>0.989</td>
<td>0.995</td>
<td>0.997 (± 0.002)</td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Black-legged kittiwake</td>
<td>Basic</td>
<td>0.989</td>
<td>0.991</td>
<td>0.992 (± 0.007)</td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>NA</td>
<td>0.980</td>
<td>0.967 (± 0.027)</td>
</tr>
<tr>
<td>Lesser black-backed gull</td>
<td>Basic</td>
<td>0.995</td>
<td>0.995</td>
<td>0.997 (± 0.002)</td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>0.990</td>
<td>0.993</td>
<td>0.992 (± 0.005)</td>
</tr>
<tr>
<td>Herring gull</td>
<td>Basic</td>
<td>0.995</td>
<td>0.995</td>
<td>0.997 (± 0.002)</td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>0.989</td>
<td>0.993</td>
<td>0.992 (± 0.005)</td>
</tr>
<tr>
<td>Great black-backed gull</td>
<td>Basic</td>
<td>0.995</td>
<td>0.995</td>
<td>0.997 (± 0.002)</td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>0.989</td>
<td>0.993</td>
<td>0.992 (± 0.005)</td>
</tr>
<tr>
<td>Little gull (and other small gulls)</td>
<td>Basic</td>
<td>0.992</td>
<td>0.992</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>All other species</td>
<td>Basic</td>
<td>0.980</td>
<td>0.980</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

\(^1\) Joint Response from the Statutory Nature Conservation Bodies to Marine Scotland Science Avoidance Rate Review, 2014


Stochastic CRM – Worked Example

Combined Outputs

Annual number of collisions - Black-legged Kittiwake

<table>
<thead>
<tr>
<th>Option</th>
<th>Mean</th>
<th>SD</th>
<th>CV</th>
<th>Median</th>
<th>2.5%</th>
<th>25%</th>
<th>75%</th>
<th>97.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1</td>
<td>217.07</td>
<td>206.787</td>
<td>0.953</td>
<td>149.168</td>
<td>10.869</td>
<td>73.638</td>
<td>300.944</td>
<td>740.091</td>
</tr>
<tr>
<td>Option 2</td>
<td>28.727</td>
<td>26.694</td>
<td>0.999</td>
<td>18.092</td>
<td>1.298</td>
<td>8.431</td>
<td>36.711</td>
<td>100.094</td>
</tr>
<tr>
<td>Option 3</td>
<td>23.033</td>
<td>21.761</td>
<td>0.945</td>
<td>16.464</td>
<td>1.666</td>
<td>8.503</td>
<td>30.934</td>
<td>78.043</td>
</tr>
</tbody>
</table>

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Stochastic CRM – Worked Example

Monthly number of collisions by model option - Black-legged Kittiwake

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean</th>
<th>SD</th>
<th>CV</th>
<th>Median</th>
<th>2.5%</th>
<th>25%</th>
<th>75%</th>
<th>97.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>1.657</td>
<td>1.643</td>
<td>0.885</td>
<td>1.408</td>
<td>0.093</td>
<td>0.644</td>
<td>2.578</td>
<td>6.043</td>
</tr>
<tr>
<td>Feb</td>
<td>0.749</td>
<td>0.941</td>
<td>1.257</td>
<td>0.440</td>
<td>0.010</td>
<td>0.174</td>
<td>0.985</td>
<td>3.281</td>
</tr>
<tr>
<td>Mar</td>
<td>10.422</td>
<td>12.454</td>
<td>1.195</td>
<td>6.198</td>
<td>0.248</td>
<td>2.320</td>
<td>13.839</td>
<td>48.106</td>
</tr>
<tr>
<td>Apr</td>
<td>9.579</td>
<td>11.298</td>
<td>1.180</td>
<td>5.372</td>
<td>0.198</td>
<td>2.387</td>
<td>12.787</td>
<td>45.045</td>
</tr>
<tr>
<td>May</td>
<td>13.464</td>
<td>15.054</td>
<td>1.118</td>
<td>8.658</td>
<td>0.284</td>
<td>3.664</td>
<td>17.308</td>
<td>58.481</td>
</tr>
<tr>
<td>Jun</td>
<td>33.948</td>
<td>39.120</td>
<td>1.152</td>
<td>21.671</td>
<td>0.935</td>
<td>8.213</td>
<td>45.799</td>
<td>133.424</td>
</tr>
<tr>
<td>Jul</td>
<td>62.399</td>
<td>69.402</td>
<td>1.112</td>
<td>38.043</td>
<td>1.359</td>
<td>14.408</td>
<td>88.664</td>
<td>264.569</td>
</tr>
<tr>
<td>Aug</td>
<td>7.095</td>
<td>7.934</td>
<td>1.118</td>
<td>4.565</td>
<td>0.215</td>
<td>1.929</td>
<td>9.211</td>
<td>30.448</td>
</tr>
<tr>
<td>Sep</td>
<td>48.802</td>
<td>64.794</td>
<td>1.333</td>
<td>28.261</td>
<td>0.715</td>
<td>10.773</td>
<td>61.662</td>
<td>227.255</td>
</tr>
<tr>
<td>Oct</td>
<td>19.039</td>
<td>18.633</td>
<td>0.864</td>
<td>14.369</td>
<td>0.955</td>
<td>6.858</td>
<td>26.020</td>
<td>82.443</td>
</tr>
<tr>
<td>Nov</td>
<td>5.951</td>
<td>5.258</td>
<td>0.884</td>
<td>4.455</td>
<td>0.297</td>
<td>2.059</td>
<td>8.274</td>
<td>19.104</td>
</tr>
<tr>
<td>Dec</td>
<td>3.987</td>
<td>4.732</td>
<td>1.193</td>
<td>2.199</td>
<td>0.058</td>
<td>0.864</td>
<td>5.288</td>
<td>17.722</td>
</tr>
</tbody>
</table>
# Stochastic CRM – Worked Example

![Graph showing number of collisions and statistical data]

### Model Option 2

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean</th>
<th>SD</th>
<th>CV</th>
<th>Median</th>
<th>2.5%</th>
<th>25%</th>
<th>75%</th>
<th>97.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>0.229</td>
<td>0.213</td>
<td>0.932</td>
<td>0.183</td>
<td>0.111</td>
<td>0.075</td>
<td>0.315</td>
<td>0.787</td>
</tr>
<tr>
<td>Feb</td>
<td>0.092</td>
<td>0.117</td>
<td>1.273</td>
<td>0.052</td>
<td>0.001</td>
<td>0.019</td>
<td>0.117</td>
<td>0.427</td>
</tr>
<tr>
<td>Mar</td>
<td>1.277</td>
<td>1.558</td>
<td>1.221</td>
<td>0.759</td>
<td>0.029</td>
<td>0.268</td>
<td>1.682</td>
<td>6.126</td>
</tr>
<tr>
<td>Apr</td>
<td>1.109</td>
<td>1.498</td>
<td>1.259</td>
<td>0.651</td>
<td>0.024</td>
<td>0.277</td>
<td>1.510</td>
<td>5.252</td>
</tr>
<tr>
<td>May</td>
<td>1.658</td>
<td>1.970</td>
<td>1.169</td>
<td>0.997</td>
<td>0.033</td>
<td>0.429</td>
<td>2.099</td>
<td>6.477</td>
</tr>
<tr>
<td>Jun</td>
<td>4.194</td>
<td>5.138</td>
<td>1.225</td>
<td>2.559</td>
<td>0.106</td>
<td>0.968</td>
<td>5.877</td>
<td>18.147</td>
</tr>
<tr>
<td>Jul</td>
<td>7.698</td>
<td>8.957</td>
<td>1.161</td>
<td>4.558</td>
<td>0.174</td>
<td>1.758</td>
<td>10.519</td>
<td>33.860</td>
</tr>
<tr>
<td>Aug</td>
<td>0.875</td>
<td>1.027</td>
<td>1.173</td>
<td>0.527</td>
<td>0.025</td>
<td>0.220</td>
<td>1.125</td>
<td>4.001</td>
</tr>
<tr>
<td>Sep</td>
<td>5.948</td>
<td>8.064</td>
<td>1.356</td>
<td>3.085</td>
<td>0.093</td>
<td>1.281</td>
<td>7.745</td>
<td>26.807</td>
</tr>
<tr>
<td>Oct</td>
<td>2.547</td>
<td>2.189</td>
<td>0.933</td>
<td>1.691</td>
<td>0.118</td>
<td>0.776</td>
<td>3.208</td>
<td>8.132</td>
</tr>
<tr>
<td>Nov</td>
<td>0.734</td>
<td>0.685</td>
<td>0.933</td>
<td>0.525</td>
<td>0.037</td>
<td>0.241</td>
<td>0.990</td>
<td>2.548</td>
</tr>
<tr>
<td>Dec</td>
<td>0.489</td>
<td>0.608</td>
<td>1.245</td>
<td>0.273</td>
<td>0.006</td>
<td>0.109</td>
<td>0.835</td>
<td>2.346</td>
</tr>
</tbody>
</table>
Stochastic CRM – Worked Example
Collision Risk Modelling:
Update on Marine Scotland Science projects

Tom Evans
Development of a stochastic collision risk model

  - Developed from SOSS Band 2012 model
  - Implemented the Band model in R (based on code from Aonghais Cook)
  - Incorporates variation and uncertainty in input parameters
  - Produces collision estimates with uncertainty by running model many times and sampling from parameter distributions
  - Requires a good knowledge of R

Development of a user friendly tool: sCRM

  - Added user friendly interface (Shiny)
  - Code improvements
  - Web based interface available: http://dmpstats.shinyapps.io/avian_stochcrm/

https://www2.gov.scot/Topics/marine/marineenergy/mre/current/StochasticCRM
Recent refinements to the sCRM tool

  - Various issues raised via the GitHub page:
    - Update to Masden code to fix issues with how up and downwind calculations used in option 3
    - Error in how flight height distribution was used (shifted by 1m)
    - Uploading a user-supplied bootstrap flight height distribution
  - New facility to compare outputs directly with Band (2012) spreadsheet
    - Runs sCRM suppressing stochastic calculations
    - Requires running app locally – see GitHub page
    - Option 1 and 2 within 0.05% of Band estimates
    - Option 3 is within approximately 0.4%

https://github.com/dmpstats/stochCRM
https://github.com/dmpstats/Masden_stochCRM
Improving estimation of parameters used to estimate collision risk of seabirds with offshore wind farms

- Marine Scotland with Crown Estate Scotland
- Under procurement
- …consider how existing data from GPS tracking of seabird species may be analysed to improve estimation of key parameters in collision risk modelling: these are flight speed, flight height, and nocturnal activity rates
Study to examine how seabird collision risk, displacement and barrier effects could be integrated for assessment of offshore wind developments

Francis Daunt, Kate Searle, Deena Mobbs (CEH), Adam Butler (BioSS)

*Contributing via workshop*: Aonghais Cook (BTO), Mark Trinder (MacArthur Green), Aly McCluskie (RSPB), Ross McGregor (HiDef), Carl Donovan & Bruno Caneco (DMP Statistical Solutions)

**Summary**

To develop a conceptual framework for simultaneous assessment of seabird collision risk, displacement and barrier effects when considering the potential impacts of offshore wind farm developments

**Stage**: Underway

**Funding**: Marine Offshore Renewable Energy branch (Marine Scotland Policy)
Current Issues and Knowledge Gaps

1. New species in ScotWind DPO’s?
2. Update required to the migratory CRM
3. Provision of seasonal outputs
4. Input parameters (as per this morning’s talk)
5. Commercial roll out will require multiple inputs for different scenarios – this is currently labour intensive.
6. Some bug catching still ongoing within the Shiny app.
Thank you