

Appendix 8.2 Collision Risk Modelling

Contents

Golden Plover (<i>Pluvialis apricaria</i>) – Random Model	1
Pink Footed Goose (<i>Anser Brachyrhyus</i>) – Linear Model	8

This page is intentionally blank.

Appendix 8.2 - Collision Risk Modelling

Golden Plover (Pluvialis apricaria) – Random Model

Stage 1: Number of Birds Flying Through the Rotors per Year

Calculate the number of hours of observation expressed in hectare hours. Where simultaneous surveys at vantage points with overlapping viewsheds have been undertaken, the area of overlap has been determined through use of GIS and the hectare hours for this area has been determined and subtracted from the total of the vantage points in order to remove double counting. Where three or more vantage points have been undertaken simultaneously, the same approach has been undertaken with the exception of where one viewshed covers the entirety of the other vantage points observed. In this instance the hectare hour for this one vantage point has been used in the calculation to avoid double counting.

Hectare hours = viewshed (to 2 km) within the site boundary (ha) * survey duration (hrs)

Vantage Point	Ha
1	98.99
2	170.42
3	86.51
4	298.18
5	198.18

Date	VP	Start Time	Hours surveyed	Ha hrs	Overlap (Ha)	Corrected Ha Hrs
05/04/2011	1	13:30	1.5	148.485	51	327.615
05/04/2011	2	13:30	1.5	255.63		
05/04/2011	3	09:00	3	259.53	5	839.07
05/04/2011	5	09:05	3	594.54		
20/04/2011	1	13:30	1.5	148.485	51	327.615
20/04/2011	1	18:35	3	296.97	51	146.97
20/04/2011	2	13:33	1.5	255.63		
20/04/2011	2	18:36	3	511.26		
21/04/2011	3	05:50	3	259.53	80	914.07
21/04/2011	4	05:50	3	894.54		
21/04/2011	4	11:15	3	894.54	133	1090.08
21/04/2011	5	11:05	3	594.54		
09/05/2011	3	18:50	3	259.53	5	839.07
09/05/2011	5	18:53	3	594.54		
11/05/2011	1	09:00	3	296.97	51	
11/05/2011	2	06:45	3	511.26		
11/05/2011	3	12:30	3	259.53	2	

Date	VP	Start Time	Hours surveyed	Ha hrs	Overlap (Ha)	Corrected Ha Hrs
11/05/2011	5	10:20	3	594.54	55	1536.05
12/05/2011	1	04:50	3	296.97	92	915.51
12/05/2011	2	11:00	3	511.26	108	1081.8
12/05/2011	4	05:00	3	894.54		
12/05/2011	4	10:45	3	894.54		
30/05/2011	2	13:00	3	511.26		770.79
30/05/2011	3	13:05	3	259.53		
30/05/2011	4	16:40	3	894.54	133	1090.08
30/05/2011	5	16:30	3	594.54		
31/05/2011	1	11:50	3	296.97		296.97
06/06/2011	1	19:45	3	296.97		296.97
14/06/2011	2	19:55	3	511.26		511.26
14/06/2011	5	04:05	3	594.54		594.54
15/06/2011	3	20:00	3	259.53		259.53
15/06/2011	4	20:00	3	894.54		894.54
16/06/2011	2	10:20	3	511.26		511.26
16/06/2011	5	14:00	3	594.54		594.54
30/06/2011	3	04:50	3	259.53		259.53
30/06/2011	4	13:30	3	894.54		894.54
30/06/2011	5	19:15	3	594.54		594.54
01/07/2011	1	04:40	3	296.97		296.97
01/07/2011	2	13:00	3	511.26		511.26
01/07/2011	3	09:30	3	259.53		259.53
08/07/2011	1	12:15	3	296.97		296.97
08/07/2011	4	04:35	3	894.54		894.54
28/07/2011	1	12:05	3	296.97	2	550.5
28/07/2011	1	16:05	3	296.97	2	
28/07/2011	3	12:00	3	259.53		
28/07/2011	3	16:00	3	259.53		
28/07/2011	5	13:00	3	594.54	55	484.54
28/07/2011	5	17:00	3	594.54	55	484.54
29/07/2011	4	15:30	3	894.54		894.54
29/07/2011	4	19:30	3	894.54		894.54
31/07/2011	2	09:30	3	511.26		511.26
31/07/2011	2	13:30	3	511.26		511.26
09/08/2011	1	15:35	3	296.97		
09/08/2011	1	19:15	3	296.97		

Date	VP	Start Time	Hours surveyed	Ha hrs	Overlap (Ha)	Corrected Ha Hrs
09/08/2011	3	15:15	3	259.53		
09/08/2011	3	19:15	3	259.53		
09/08/2011	4	15:15	3	894.54		
09/08/2011	4	19:15	3	894.54		1789.08
19/08/2011	2	04:55	3	511.26		511.26
19/08/2011	2	08:55	3	511.26		511.26
08/09/2011	3	12:55	3	259.53	80	914.07
08/09/2011	3	16:55	3	259.53	80	914.07
08/09/2011	4	12:55	3	894.54		
08/09/2011	4	16:55	3	894.54		
16/09/2011	1	08:15	3	296.97	55	726.51
16/09/2011	1	12:15	3	296.97	55	726.51
16/09/2011	5	08:40	3	594.54		
16/09/2011	5	12:40	3	594.54		
26/09/2011	2	08:34	3	511.26		511.26
26/09/2011	2	12:40	3	511.26		511.26
21/10/2011	1	12.05	3	296.97	55	1930.08
21/10/2011	1	16.05	3	296.97		
21/10/2011	3	12:05	3	259.53	2	
21/10/2011	3	16:05	3	259.53		
21/10/2011	5	12:05	3	594.54	5	
21/10/2011	5	16:05	3	594.54		
27/10/2011	2	09:30	3	511.26		511.26
27/10/2011	2	13:30	3	511.26		511.26
31/10/2011	4	09:45	3	894.54		894.54
31/10/2011	4	13:45	3	894.54		894.54
11/11/2011	1	10:20	3	98.99		1074.54
11/11/2011	1	14:20	3	296.97		1074.54
11/11/2011	3	10:20	3	259.53		
11/11/2011	3	14:20	3	259.53		
11/11/2011	4	10:20	3	894.54		
11/11/2011	4	14:20	3	894.54		
11/11/2011	5	10:20	3	594.54		
11/11/2011	5	14:20	3	594.54		
21/11/2011	2	09:30	3	511.26		511.26
27/11/2011	2	13:00	3	511.26		511.26
20/12/2011	1	07:40	3	296.97		894.54

Date	VP	Start Time	Hours surveyed	Ha hrs	Overlap (Ha)	Corrected Ha Hrs
20/12/2011	1	11:40	3	296.97		894.54
20/12/2011	3	07:45	3	259.53		
20/12/2011	3	11:45	3	259.53		
20/12/2011	4	07:40	3	894.54		
20/12/2011	4	11:40	3	894.54		
23/12/2011	2	07:40	3	511.26		
23/12/2011	2	11:40	3	511.26		
23/12/2011	5	07:40	3	594.54	170.42	594.54
23/12/2011	5	11:40	3	594.54	170.42	594.54
11/01/2012	1	10:10	3	296.97	5	541.5
11/01/2012	1	14:10	3	296.97	5	541.5
11/01/2012	3	10:10	3	259.53		
11/01/2012	3	14:10	3	259.53		
12/01/2012	2	15:15	3	511.26		511.26
13/01/2012	2	12:00	2	340.84		340.84
13/01/2012	2	14:30	2	340.84		340.84
15/02/2012	5	10:10	3	594.54		594.54
15/02/2012	5	14:00	3	594.54		594.54
17/02/2012	2	12:00	2	340.84	108	1073.38
17/02/2012	2	14:30	1.5	255.63	108	988.17
17/02/2012	4	10:35	3	894.54		
17/02/2012	4	14:35	3	894.54		
22/02/2012	1	11:00	3	296.97		296.97
22/02/2012	1	15:00	3	296.97		296.97
24/02/2012	3	11:40	3	259.53		259.53
24/02/2012	3	15:40	3	259.53		259.53
12/03/2012	1	12:05	3	296.97		1074.54
12/03/2012	1	16:05	3	296.97		1074.54
12/03/2012	3	12:05	3	259.53		
12/03/2012	3	16:05	3	259.53		
12/03/2012	4	12:05	3	894.54		
12/03/2012	4	16:05	3	894.54		
12/03/2012	5	12:15	3	594.54		
12/03/2012	5	16:15	3	594.54		
19/03/2012	2	07:00	2	340.84		340.84
19/03/2012	2	09:30	2	340.84		340.84
19/03/2012	2	12:00	2	340.84		340.84

Date	VP	Start Time	Hours surveyed	Ha hrs	Overlap (Ha)	Corrected Ha Hrs
20/04/2012	3	16:30	3	259.53		259.53
21/04/2012	2	07:30	3	511.26		511.26
21/04/2012	2	16:30	3	511.26		511.26
22/04/2012	3	07:05	3	259.53		259.53
Total						51536.86

Calculate hectare seconds = hectare hrs * 3600
= 51536.86 * 3600
= 185532696 Hectare seconds

Calculate the bird observation in all areas and percentage of time birds active in overall observed area.

Date	No.	VP	HB1	HB2	HB3 (PCH)	HB4	Total flight time (at PCH) in seconds
26/09/2011	12	2	0	30	0	0	360
21/04/2012	23	2	0	0	75	0	1725
21/04/2012	1	2	0	25	0	0	25
21/04/2012	14	2	45	85	0	0	1190
21/04/2012	14	2	45	75	140	0	3010
21/04/2012	2	2	5	30	0	0	60
21/04/2012	2	2	30	180	30	0	420
21/04/2012	53	2	0	0	210	0	11130
21/04/2012	29	2	15	35	0	0	1015
23/12/2011	20	5	0	120	0	0	2400
Total							21335

Bird Activity = Total bird flight time / hectare seconds

BA = 0.000114993

Overall Area covered by VPs (excluding overlap) = 363 Ha

Calculate the number of hrs per day birds are potentially active over a year and the number of hrs of bird occupancy in the airspace per year

$$\begin{aligned} \text{hrs potentially active (12 months daylight hours plus 25\% night time hours)} &= 5337.86 \\ \text{seconds potentially active} &= 5337.86 * 3600 \\ &= 19216296 \end{aligned}$$

$$\begin{aligned} \text{no of seconds of bird occur in airspace} &= \text{sec potentially active} * \text{bird activity} \\ &= 19216296 * 0.000114993 \\ &= 2209.740 \end{aligned}$$

Calculate flight risk volume (Vw)

$$\begin{aligned} V_w &= 3631290 \text{ (m}^2\text{)} * \text{rotor diameter (m)} \\ V_w &= 366760290 \end{aligned}$$

Calculate combined rotor swept volume

$$\begin{aligned} V_r &= \text{number of turbines (n)} * \pi * r^2 * (\text{max chord} + \text{bird length}) \\ V_r &= 24 * (\pi * 2550.25) * (3.5 + 0.28) \\ V_r &= 726466.255 \end{aligned}$$

Calculate bird occurrence in swept volume

$$\begin{aligned} \text{Occurrence} &= \text{no of sec of bird occ} * \text{combined rotor swept volume} / \text{flight risk volume} \\ &= 2209.7395 * (V_r / V_w) \\ &= 2209.740 * (726466.255 / 366760290) \\ &= 4.375 \end{aligned}$$

Calculate bird transits time and potential number of transits per year

$$\begin{aligned} \text{Transit time} &= (\text{max chord} + \text{bird length}) / \text{bird speed (m}^2\text{)} \\ &= (3.5 + 0.28) / 10 \\ &= 0.378 \end{aligned}$$

$$\begin{aligned} \text{No. of transits} &= \text{occurrence} / \text{transit time} \\ &= 4.375 / 0.378 \\ &= 11.574 \end{aligned}$$

Pink Footed Goose (Anser Brachyrhyus) – Linear Model

Stage 1: Number of Birds Flying Through the Rotors per Year

1. Calculation of the 'risk window'; Cross section area equal to the width of the wind farm across the general direction of flight multiplied by the height of turbine to rotor tip. Width of wind farm was determined using GIS.

$$\begin{aligned}\text{Width of transit flight (Ws)} &= 2676\text{m} \\ \text{Turbine height (th)} &= 125\text{m} \\ \\ \text{Risk Window (W)} &= Ws * th \\ &= 2676\text{m} * 125\text{m} \\ &= 334500\text{m}^2\end{aligned}$$

2. Calculate the area occupied by rotor blades (A)

$$\begin{aligned}\text{Number of turbine (n)} &= 24 \\ \text{Rotor radius (r)} &= 50.5 \\ A &= n * \pi * r^2 \\ A &= 24 * 3.14 * 2550.250 \\ A &= 192186.840\text{m}^2\end{aligned}$$

3. Express the area occupied by rotor blades (A) as a proportion of the risk window (W)

$$\begin{aligned}\text{Proportion (P)} &= A/W \\ &= 192186.840/334500 \\ &= 0.575\end{aligned}$$

4. Calculate the number of bird potentially flying through the site per year (N)

$$\begin{aligned}N &= \text{number of pink footed goose transits at PCH per year} \\ &= \text{hourly rate of transit} * \text{available hours for flight}\end{aligned}$$

Hours surveyed between September 2011 and March 2012

$$\begin{aligned}&= \text{hectare hours (correcting for overlap) / hectares visible in Study area} \\ &= 51536.860 / 363 \\ &= 141.975\end{aligned}$$

Number of geese observed in the same period = 134

$$\begin{aligned}\text{Hourly rate of transit} &= 134/141.975 \\ &= 0.944\end{aligned}$$

Hours available for flight are equal to number of daylight hours in the same period plus 25% of night hours. Daylight and night hours taken from time and date website and based on Glasgow (www.timeanddate.com/worldclock/sunrise.html) accessed 21.03.11.

Calculation of collision rate

$$\begin{aligned}\text{Collision rate} &= Nf * \text{average probability of collision} \\ &= 1533.530 * 0.085 \\ &= 130.350\end{aligned}$$

Calculation of collision rate applying 99.8% avoidance rate

$$\begin{aligned}&= 130.350 * 0.002 \\ &= 0.261\end{aligned}$$

1. Correct collision rate for down time (assuming wind farm operates at 85%)

$$\begin{aligned}&= (0.261 / 100) * 85 \\ &= 0.222\end{aligned}$$

2. Calculate the number of year per collision

$$\begin{aligned}&= 1 / 0.222 \\ &= 4.505\end{aligned}$$

3. Calculate the number of collisions per lifetime of the scheme

$$\begin{aligned}&= 0.22 * 25 \\ &= 5.55\end{aligned}$$