Monitoring of wintering geese in the AES Geo Energy Wind Park "Sveti Nikola" territory and the Kaliakra region in winter 2009/2010

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EXECUTIVE SUMMARY

During the summer of 2008, AGE OOD (AGE), developer of the Saint Nikola Wind Farm (the Project), was made aware that winter bird survey records for the region, during 2007/2008, had shown what appeared to be potentially significant winter flight activity in the general area of the proposed development. Of particular interest was the reported presence of the Red-breasted Goose (RBG), a globally threatened species. Recognising the importance of RBG in particular, as part of the ongoing works and environmental commitments associated with the Project, AGE undertook to carry out bird surveys during the 2008/2009 winter season, prior to operation of the Project. The survey resulted in the first estimation of the number of geese flying through the wind park territory and a Collision Risk Model predicting potential RBG mortality as a result of colliding with operating turbine blades. As a result it was proposed to have a second winter season survey during the post construction and operation of the wind park with the application of the radar provided in line with EMMP and requirements of Bulgarian Ministry of Environment and Waters.

The following main goals were set for the 2009/2010 survey:

1. Record winter bird activity specific to the Project area (the 2008/2009 survey highlighted potential activity in the region, but the data were not sufficient with respect to Collision Risk Assessment Model);
2. Ascertain whether there is potential for the constructed already wind park to have a significant adverse effect on the wintering birds (with a particular focus on RBG);
3. In the event that a significant adverse effect was predicted, what mitigation measures would be required to reduce the effect to an acceptable level.

The wintering period of the geese in the region started in the middle of December 2009 (early January in the Project area) and ceased by the end of February 2010. Greater White-fronted Goose (GWFG) was the most common species recorded, and the percentage occurrence of RBG in goose flocks was about 10 %. Greylag Goose was recorded sporadically and in small numbers and was not therefore considered at risk from the project. Lesser White-fronted goose was not recorded. The duration of the winter stay in the study area was similar for both RBG and GWFG with a concentration of over 90% of RBG being seen within 20 days, corresponding to the coldest period of the winter. These results were similar to those from the 2008/2009 winter.

The flight altitudes of the geese from all species observed crossing the Project area were most intensive between 50 and 100 m above ground level. Flight activity of geese was greatest in the morning (7-9h) and, to a lesser extent, evening (16-18h). These findings were also similar in the 2008/2009 winter.

The results of the Collision Risk Assessment in 2008/2009 was based on an assumption of over 65,000 flights of RBG through the Project area and predicted 22 RBG collisions per year, applying a precautionary 99% avoidance rate. This prediction fell short of the threshold number of collisions (31) that would need to occur to result in a significant impact. While the threshold criterion is flawed and requires replacement with a more appropriate alternative, in the interim it follows the EMMP.

The number of RBG flights (30,500 flights detected by the radar) during the 2009/2010 winter, when used in a Collision Risk Assessment, predicted 1 – 9 RBG annual collisions (the range given by different assumed avoidance rates). This result suggests that the Project does not have the potential to have an adverse impact upon the RBG population.

A contributory explanatory factor to the differing predictions between the two winters, despite several other similarities, is likely to be the improved survey methods employed in the 2009/2010 winter study. Use of the Black Sea as a roost site by geese had been previously suggested as a factor that could increase collision risk, but the 2009/2010 results suggest that this is not the case.

Further refinements will be possible once monitoring of collision victims occurs in the 2010/2011 winter and in bringing in results from the study of GWFG as well as RBG.

INTRODUCTION

Background

AES Geo Energy OOD (AGE) have constructed the Saint Nikola Wind Farm (the Project) consisting of 52 turbines (at 105m hub height and 150m tip height) in north-east Bulgaria, approximately 3-5 km inland from the Black Sea coast (Fig. 1). The Project area is close to the three main roosting sites of four goose species during the winter period December – February). This report presents the results of the second monitoring of wintering bird (goose) activity as detailed in the AGE's Environmental Monitoring and Management Plan (EMMP) for the Project. The protocol for the study aimed at recording qualitative and quantitative information about the characteristics of the wintering goose activity in the Project area concerning Collision Risk Assessment Model. This information was recorded to provide accurate, robust and objective data to inform a Collision Risk Assessment to assess the possible impacts of the wind farm on wintering goose species.

Species Information

Detailed information for all species of geese as well as their behavioural characteristics was given in winter survey report 2008/2009 and is not repeated here.

Study Objectives

The Red-breasted Goose (*Branta ruficollis*) (RBG) is classed as globally endangered by the IUCN and threatened by BirdLife International (2004, 2005). The hinterland of the western Black Sea coast, including Bulgaria, is the main wintering ground of RBG, where flocks co-exist with other goose species, roosting on freshwater lakes and commuting to and from agricultural fields to feed during the day. Previous surveys have established that the area occupied by the Saint Nikola Wind Farm (SNWF) can be used by feeding RBG and this will therefore create a potential risk of mortality through goose flights leading to collision with moving rotor blades once the wind park becomes operational (Zehtindjiev et al. 2009, hereafter termed "the 2008/09 winter report"). This risk was modelled by the 2008/09 winter report which concluded that whilst predicted mortality was not "significant" the risk was such that mitigation measures needed to be available to avoid any possibility of an adverse impact on the RBG population.

Subsequently, the primary mitigation measure which has been developed involves the option for a turbine shutdown system (TSS), should it be required (refer to EMMP). The collision risk modelling was, nevertheless, based on a number of assumptions which require further study and refinement in order that the need for any mitigation measures, including a threshold for TSS implementation, can also be refined.

The following objectives were selected:
1. Record winter bird activity specific to the Project area with respect to Collision Risk Assessment Model;
2. Ascertain whether there is potential for the constructed wind park to have a significant adverse effect on the wintering birds (with a particular focus on RBG);

3. In the event that a significant adverse effect is predicted, identify mitigation measures, notably the TSS, that would be required to reduce the effect to an acceptable level.

Experience gathered during the 2008/09 study, and a need to refine the survey methods to replace some previous assumptions with empirical information, led to several differences between the 2008/09 study and the (present) 2009/10 study, as follows:

- While the 2008/09 study spent considerable effort in recording geese and their activity at roosting lakes to the north of the Project area, this effort was not repeated in 2009/10 because: a) the previous work had already established that goose activity levels in the Project area was related to numbers using roosts to the north; b) reduction of observation effort around roosts in 2009/10 meant more could be concentrated on the area of concern, in and around the Project area; c) concentrating effort on the Project area, in turn, meant that assumptions on flight activity made by extrapolation in 2008/09 (e.g. flights during mid-day) could be replaced by observations in 2009/10.
- The use of a radar in 2009/10 allowed improved measures of goose flight activity in and around the Project area by providing continuous coverage and by obtaining records of flight height with known (high) accuracy.

METHODS

Study area

The Project area is located in NE Bulgaria, close to the Black Sea coast near the cape of Kaliakra. It lies between the roads from the village of Bulgarevo to St. Nikola (municipality of Kavarna), and the 1st class road E 87 Kavarna – Shabla (Fig.1). The Project area consists mainly of arable land of various crops, crossed by roads and shelter belts. The area is outside the Kaliakra NATURA 2000 site.

In order to collect information on the large scale movements of the wintering geese and their habits within the Project area, the survey and monitoring were set up to cover an area (study area) wider than but including the Project area (footprint of the wind park) and adjacent agricultural fields (Fig. 1).

Figure 1. Study area showing the monitoring area (red dashed line) and the location of the main roosting sites of geese: Durankulak, Shabla and Tuzla Lakes. The Project area is shown in blue.

Duration, personnel and equipment

The 2009/10 study repeated the same survey period as in the 2008/09 winter, 10 December 2009 to 28 February 2010, covering a total of 78 days. This involved the period of the most intensive movements of wintering geese in the region of northern Bulgarian Black Sea coast (Dereliev et al. 2000, Georgiev et al. 2008). For the purpose of this study the geese were grouped by species. This conditional division was made to allow a focused study of birds of conservation importance, namely RBG and Lesser White-fronted Goose *Anser erythropus*, although data on Greater White-fronted Goose *Anser albifrons* were also collected.

As noted above, counts of geese performed during the early mornings at take-offs from the roosting sites and during their evening return, were more limited and less systematic than in 2008/09. Hence, in 2009/10 periodic observation effort at the roosting lakes was primarily devoted to identifying when geese (including RBG) had arrive in and departed from the wider region.

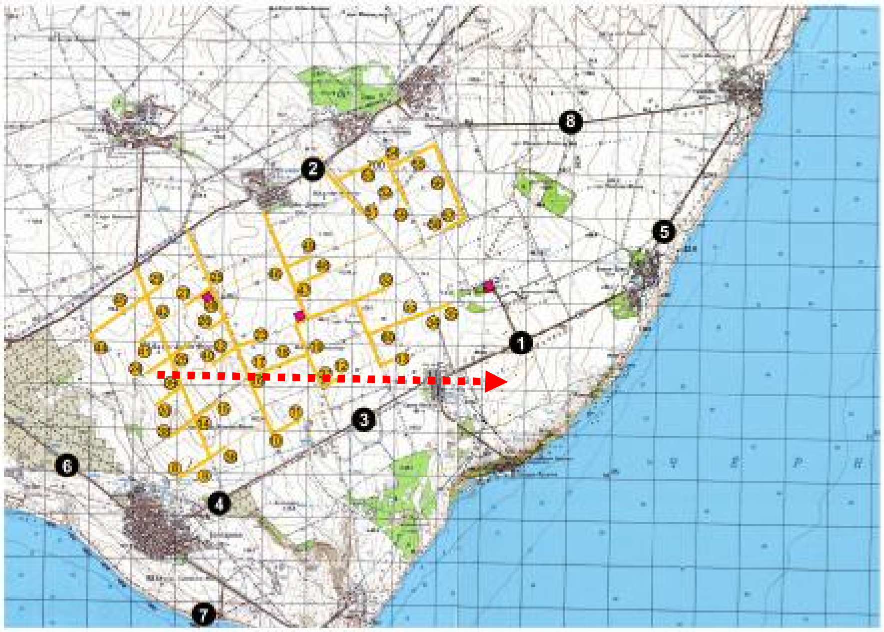

Figure 2. Location of the Project area in relation to the fixed Vantage Points (1 - 8) and the sector scanned by the radar (red dashed line).

Field observations followed census techniques according to Latta et al. (2005). Direct visual surveys of all passing birds were made daily from eight Vantage Points around the Project area (black dots: Fig. 2). Point counts were performed by scanning the sky in all directions but focussed on the Project area and birds heading towards it.

Although reasonably effective, the visual observations at each fixed counting point on their own could not encompass the whole area of interest. Hence, the visual point surveys were supplemented by itinerant surveys throughout the Project area and surrounding agricultural fields, made as-and-when birds were seen to enter the Project area or its vicinity, and at least daily. Itinerant surveys were undertaken primarily to count and identify birds to species on the ground, thereby allowing the numbers of wintering geese feeding in the Project area and its environs to be ascertained. The overall number of birds per species was obtained by collating counts made simultaneously from at least three observation points.

All observers were qualified specialists carrying out the surveys of bird migration for many years. All observers are active members of BSPB (BirdLife Bulgaria), and included:

Dimitar Vladimirov Dimitrov
PhD student in Institute of Zoology, BAS,
Member of the BSPB since 2000

Victor Metodiev Vasilev
Senior researcher in the faculty of Biology

University of Shumen, Bulgaria
Member of BSPB since 1992

Dr. Mihaela Nikolova Ilievaна
Junior researcher in Institute of Zoology, BAS
Member of BSPB since 1999

Ivailo Antonov Raykov
Museum of Natural History, Varna
PhD student,
Member of BSPB since 1999

Veselina Ivanova Raykova
Museum of Natural History, Varna
Researcher
Member of BSPB since 1999

The surveys were carried out using 10x binoculars and standard Admiral 20 – 60x telescopes, compass, GPS and digital camera.

Types of data collected

During the surveys the following data were recorded:

- Species of birds
- Number of birds
- Distance of the flying birds from the observer
- Altitude of birds
- Direction of the flight
- Behaviour of the birds in relation to other existing wind farms in the region
- Other behavioural observations
- Weather conditions

Species

All geese flying in the surveyors' scope of view were identified to the level of species, if possible, and recorded. Because of the difficulty in distinguishing between similar species in harsh conditions (e.g. poor visibility, great distance, etc.), if exact identification was not possible both possible species were written down. If there was the possibility of a single RBG in a large flock of Greater White-fronted Geese then this was still recorded as an *Anser/Branta* flock. The proportions of RBG in flocks were also calculated using observations of mixed species flocks on the ground. Due to the greater precision of ground counts gathered during itinerant surveys, analytical preference was given to data collected on species composition by this method.

Numbers of geese

Surveyors counted all geese flying in their scope of view, regardless of the possibility of identification to species or higher taxonomic order (as described in the previous paragraph). For single birds or small flocks the number of birds and species composition were recorded according to units of individual birds. In larger flocks, when the counting of every single individual was impossible, numbers and composition were recorded according to units of 10 birds.

Distance from observer and flight height

The location of flying birds (distance from the observer) and their flight height were essential measures in order to determine whether flocks' flight lines and their height above ground would potentially make birds at risk of collision. The distance from the observation point was recorded for each bird or flock seen. The flight altitude of every single bird or flock was also recorded according to fixed bands of height.

Recording of both measures was facilitated by thorough familiarisation of the observers with the geography of the study area prior to observations starting. This familiarisation process included use of numerous land marks, their position and height relative to Vantage Points. The distance to land marks and their height were measured and calibrated in advance using GPS in the field and by reference to a topographic map on which they were notated.

Flight direction

The flight direction of birds was recorded according to 16 pre-defined geographic categories on which the birds were heading with respect to the observation point (each category corresponding to 22.5 degrees of the compass). These records were again facilitated by reference to land marks. The 16 categories were as follows: N (north), NNE (north-northeast), NE (northeast), ENE (east – northeast), E (east), NSE (east – southeast), SE (southeast), SSE (south – southeast), S (south), SSW (south – southwest), SW (southwest), WSW (west – southwest), W (west), WNW (west – northwest), NW (northwest), NNW (north – northwest). For the purposes of data entry and analysis, the direction of birds' flight was described in degrees.

Behaviour of birds in relation to other existing wind farms and other behavioural observations

In addition to surveys of the Project area and the vicinity, observations were also made during itinerant surveys, where possible, in relation to bird behaviour at other nearby operational wind farms, such as geese displaying avoidance behaviour in the vicinity of turbines. These were recorded and described in detail. Additional observations concerning feeding and resting activities of birds were recorded during itinerant surveys.

Weather conditions

As weather likely affects the behaviour of the geese and thus potentially the objectivity of the surveys, the following measures were recorded:

- Wind direction
- Wind strength
- Air temperature
- Precipitation
- Visibility

Weather data were recorded at the start and end of each daily survey session as well as any time after the start when a considerable change in visibility occurred, such as created by episodes of fog or mist. Visibility was defined as the maximum distance (in metres) at which permanent land marks at known distance could be seen. Wind direction and strength as well as temperature were precisely measured by AGE through anemometer masts and kindly offered for analysis of data.

Recording and storage of data

The protocol adopted for the purposes of primary data processing was a modified version of the Protocol of Risk and Bird Mortality, used by the National Laboratory for Renewable Energy Sources of the USA (Morrison 1998). All the data were captured in a daily diary by each observer which were then processed and entered daily into an Excel database.

The diary was kept in the following manner:

1. At the start of each survey, the date and the exact hour were entered (the data were recorded by the astronomic hour, which is 1 hour behind the summer hour schedule, during the whole period of the study), as well as the name of the surveyor.
2. When detecting a bird or flock, observers first recorded the exact hour and minute, followed by the species, then the number of birds by species (see above), the horizontal distance from the watch point, flight altitude and the flight direction. After these obligatory data were recorded, additional notes on formation of flocks, landing birds with the exact location of landing etc., were also recorded. If any changes in weather or other interesting and/or important phenomena were observed, they were also entered in the diary with the exact time of the observation.
3. When finishing the daily survey, the exact time, weather conditions and the name of the surveyor were recorded again.

Radar Observations

The radar (Bridgemaster 65825H: Swiss BirdScan MS1) was a fixed pencil beam system, especially developed for the study of bird migration by the Swiss Ornithological Institute (http://www.vogelwarte.ch/home.php?lang=e&cap=projekte&subcap=vogelzug&file=../detailprojects.php&projId=583) with the following specifications:

Transmitter Power:	25kW
Magnetron Frequency:	9410MHz, ±30MHz
Pulse Length / PRF:	0.05 µsec / 1800Hz (Short Pulse) 0.25 µsec / 1800Hz (Medium Pulse) 0.75 µsec / 785Hz (Long Pulse)
Pulse Generator:	Solid state with pulse forming network
Receiver type:	logarithmic with Low Noise Front End (LNFE)
Tuning:	AFC / Manual
Intermediate Frequency:	centred at 60MHz
Bandwith:	20MHz on short and medium pulses 3MHz on long pulse
Noise Factor:	5dB
Dynamic Range:	80dB

Weight: approx. 500 kg, excl. two wheeled trailer
Power connection standard: 1-phase 230V / approx. 1kW
Detection range: approx. 5 km (for small passerines) up to 7.5 km (for larger birds)

The radar operated continuously during daylight hours (06-21 hrs GMT) from 15 December 2009 to 28 February 2010 at a location designed to maximise coverage and minimise ground clutter confusion (Fig. 2). All radar observations were at 30 mills, as low as ground clutter permitted (equivalent to approximately 25-275 m elevation at 5 km distance). This recorded all flights of geese in the vicinity of the wind farm during the study period.

The 2009/10 winter survey coincided with the testing period of the wind park prior to full operational capacity. In the event of large flocks of geese approaching groups of turbines in operation it was therefore essential to have a plan for coordinated actions with the wind park operator during the winter in case the level of flight goose activity, informed by measures described in the EMMP, would require TSS mitigation. Hence, an interim TSS was discussed and synchronised with AES Geo Energy in November and was applied during the winter survey.

RESULTS

In keeping with previous records and published literature from the region, the 78 days of the study encompassed the whole period when geese were recorded in the wider region during 2009/10.

Total number of observed goose species and their numbers

Over 250,000 individual bird observations were recorded during the surveys (Table 1). In total, three species of goose were observed: RBG; Greater White-fronted Goose (GWFG) and Greylag Goose *Anser anser*. Additionally, two species of swans (*Cygnus* spp.) were observed (Table 1), but in such small numbers that their presence was not considered further. No Lesser White-fronted Geese were seen.

Table 1. The number of observed birds of different species (data from visual observations).

Sum of number in flocks:	Species					
Date	A.albifrons	A.anser	B. ruficollis	C. cygnus	C. olor	Grand Total
03.1.2010 - 12.1.2010	40471		327			40798
13.1.2010 - 22.1.2010	33064		1229	13		34306
23.1.2010 - 01.2.2010	11400	100	9467	138	64	21169
02.2.2010 - 11.2.2010	24933	53	13313	17		38316
12.2.2010 - 21.2.2010	4056		731		3	4790
Grand Total	113924	153	25067	168	67	139379

Table 2. Average proportion of the geese species registered during the study (based on numbers of birds presented in Table 1).

Date	A.albifrons	A.anser	B. ruficollis	Grand Total
03.1.2010 - 12.1.2010	99.2%	0.0%	0.8%	100%
13.1.2010 - 22.1.2010	96.4%	0.0%	3.6%	100%
23.1.2010 - 01.2.2010	54.4%	0.5%	45.2%	100%
02.2.2010 - 11.2.2010	65.1%	0.1%	34.8%	100%
12.2.2010 - 21.2.2010	84.7%	0.0%	15.3%	100%
Grand Total	81.9%	0.1%	18.0%	100%

The proportion of the GWFG and RBG varied during the study period. In Table 2 the proportion of these two species is presented in 10 day periods. Greylag Geese (*A.anser*) were comparatively low in number (153 birds), which equates to a proportion from 0 to 0.5% of all observed geese.

Spatial distribution of feeding geese in the wind park territory

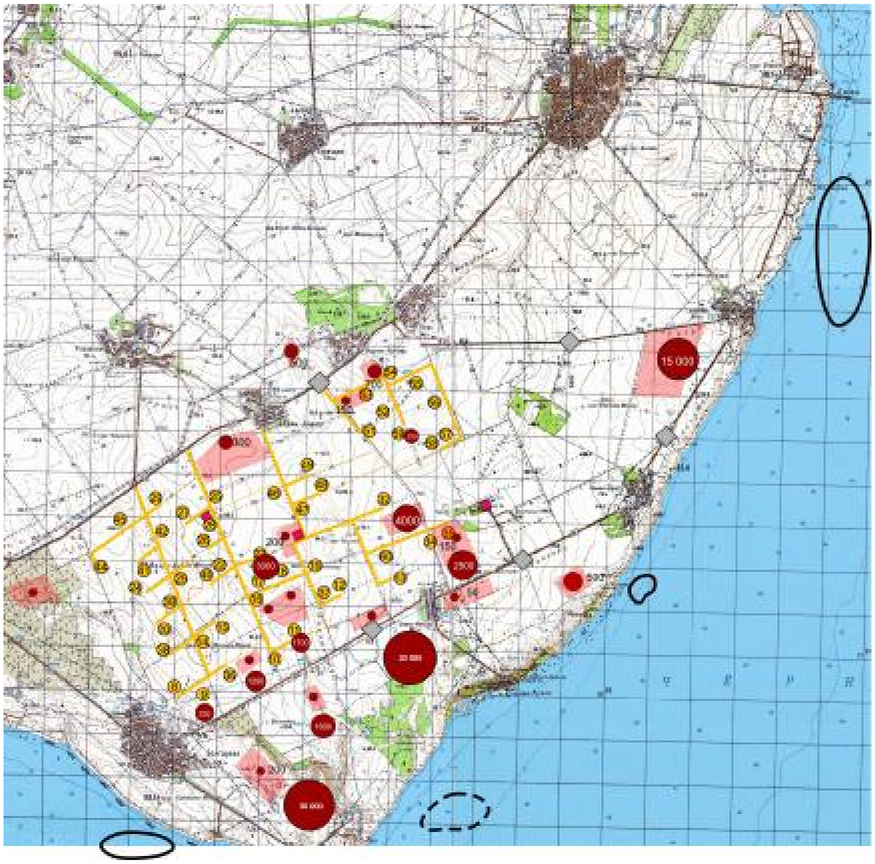

Figure 3. The distribution of the feeding geese in mixed flocks (RBG and GWFG) in relation to the Project area. The maximum recorded number during the season is given. The main roosting sites in the sea are given with a solid line, with a dashed line indicating a more temporary roosting site.

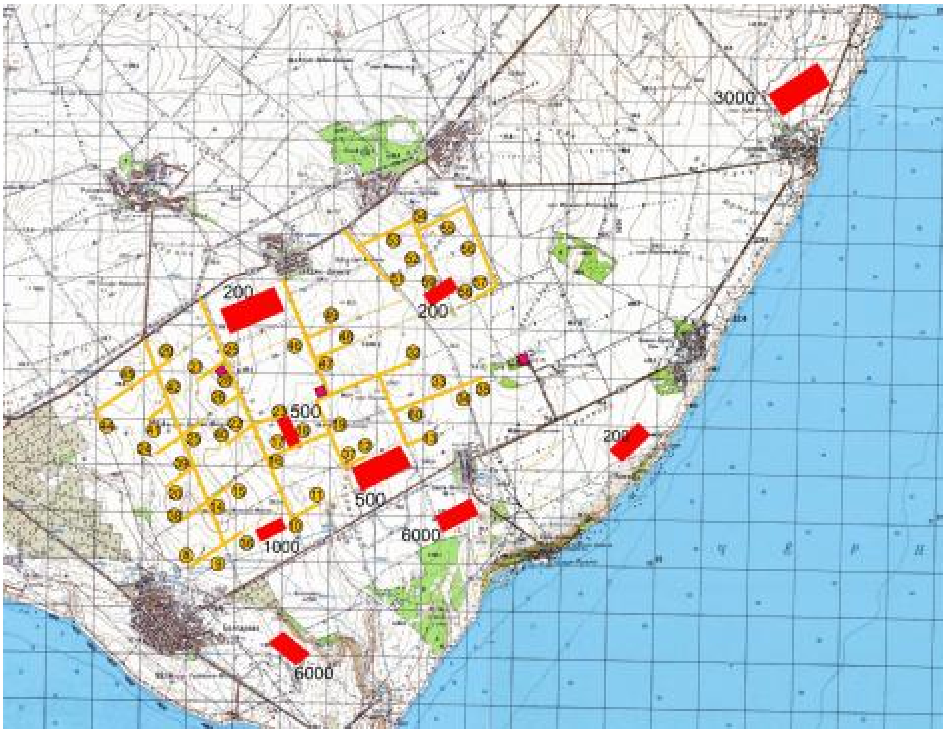

Figure 4. The distribution of feeding RBG in relation to the Project area. The maximum registered number during the season is given.

Geese were registered in the Project area from 03 January 2010 until 21 February 2010. The main roosting sites and the locations used by the geese in relation to the Project area are presented in Figures 3 and 4.

Altitudinal distribution of flying geese

298,938 individual observations were included in the analysis of the flight altitudes. The majority of birds were observed flying at altitudes between 100 and 300 metres above ground level (51 %: Table 3). The species variations in the altitudes are not statistically significant. This distribution includes birds observed during all hours of the day. Therefore, the altitudes of the bird flights represented all kinds of functional flights and the whole spectrum of spatial trends seen during the winter season. The average altitudes measured in relation to activity within the Project area corresponded with the identified feeding territories in the study area (Fig. 3 and 4). The lower flights were more often recorded around the fields with registered feeding geese. The rest of the study area was used by geese during their higher transit flights to the feeding grounds elsewhere.

Flight altitude was also recorded by the radar, and the frequency distribution of flight heights is illustrated in Table 4.

Table 3. Comparative distribution of the flight altitudes of all geese species observed in the wind park territory from the vantage points (N = 197184 birds).

	Species				
Altitude (m)	A.albifrons	A.anser	Anser/Branta	B. ruficollis	Grand Total
0	3%	8%	0%	17%	3%
10	0%	3%	0%	0%	0%
20	3%	4%	5%	3%	4%
30	4%	14%	17%	8%	11%
40	2%	0%	2%	3%	2%
50	30%	48%	22%	34%	27%
60	0%	0%	1%	0%	0%
70	0%	0%	0%	2%	0%
80	2%	0%	0%	12%	2%
100	25%	24%	21%	17%	23%
120	0%	0%	1%	0%	0%
150	7%	0%	28%	3%	16%
200	15%	0%	4%	1%	8%
250	4%	0%	0%	0%	2%
300	4%	0%	0%	0%	2%
N by species	82986	133	93004	21061	197184

Table 4. Flight altitudes of geese registered by the radar (N = 1477 flocks).

Altitude (m)	Proportion	Number of detected geese
0-49	2%	5700
50-99	20%	60110
100-149	41%	121940
150-199	30%	89120
200-250	7%	19550
Grand Total	100%	296420

It was apparent that observers were probably more likely to record particular flight heights so, for example, there were ‘spikes’ in the frequency of records at altitudes of 50 m and 100 m (Table 3, Fig. 5). This potential bias should only become a problem in terms of assessing the potential collision risk if: a) there is a reliance on the observer data for collision risk modelling and, more importantly; b) the bias markedly affected the accuracy of the recorded frequency of flight at collision risk height.

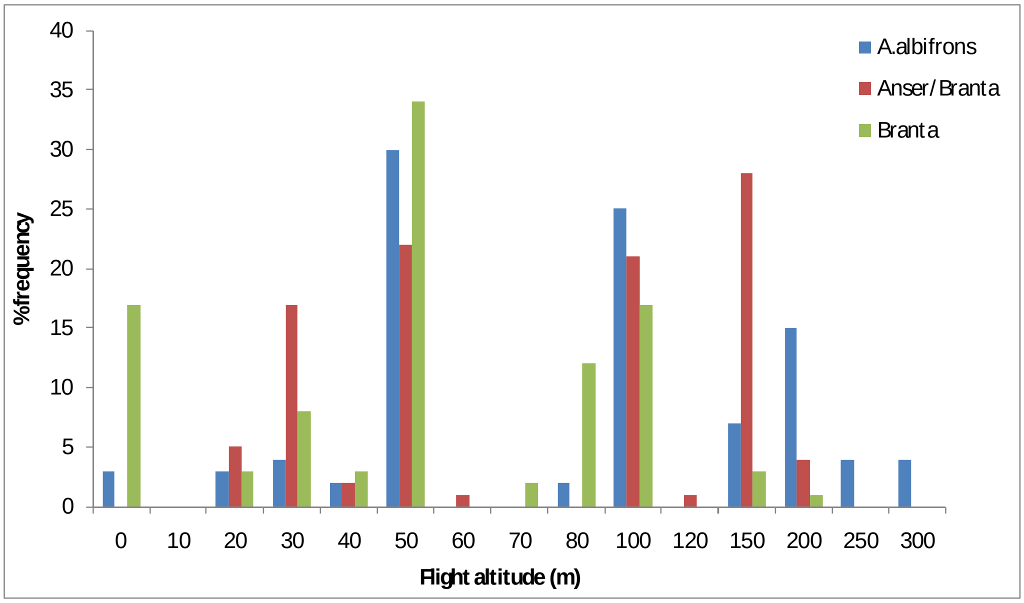

Figure 5. Flight altitudes of geese recorded by observers according to species (see also Table 3).

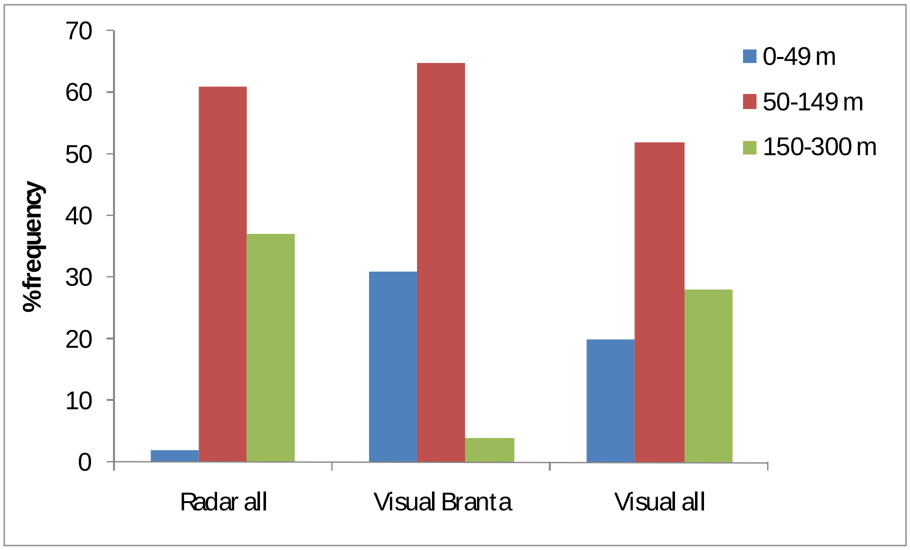

Figure 6. Comparison of the frequency at which the radar and observers (visual) recorded flight height of geese, according to three height bands.

As there was greater certainty in the flight heights recorded by the radar (Table 4) it was instructive to compare the heights measured by radar with those measured visually (Fig. 6). From this it was apparent that observers tended to record more flights close to the ground (< 50 m) whereas the radar documented more flights above rotor swept height (> 150 m) (Fig. 6). This is perhaps to be expected since observer attention was more focussed on birds coming into the wind farm to feed (at low level), whereas the radar could detect higher flying birds at greater distance. Most importantly, however, in context of modelling collision risk, the two methods gave very similar results for the proportion of birds flying at risk height (crudely approximating to 50 – 149 m, in Fig. 6). This gave confidence in this important input parameter of collision risk modelling.

Temporal distribution of goose records

The first observations of the geese at the main roosting sites in region of the Durankulak and Shabla Lakes were from 17 December 2009. The first confirmed registration of RBG near the Project area was on 27 December 2009. For the analysis of temporal distribution of the geese in the Project area the data from the Vantage Points around the Project area were employed. The proportions of the different species in the total number of geese registered varied during the season (Table 5). The majority of RBG (over 90%) were concentrated in 20 days of the winter (23 January 2010 – 11 February 2010).

Table 5. Proportion of the geese species during the winter season 2009/2010.

Date	A.albifrons	A.anser	B. ruficollis	Grand Total
03.1.2010 - 12.1.2010	36%	0%	1%	29%
13.1.2010 - 22.1.2010	29%	0%	5%	25%
23.1.2010 - 01.2.2010	10%	65%	38%	15%
02.2.2010 - 11.2.2010	22%	35%	53%	28%
12.2.2010 - 21.2.2010	4%	0%	3%	3%
Total	100%	100%	100%	100%

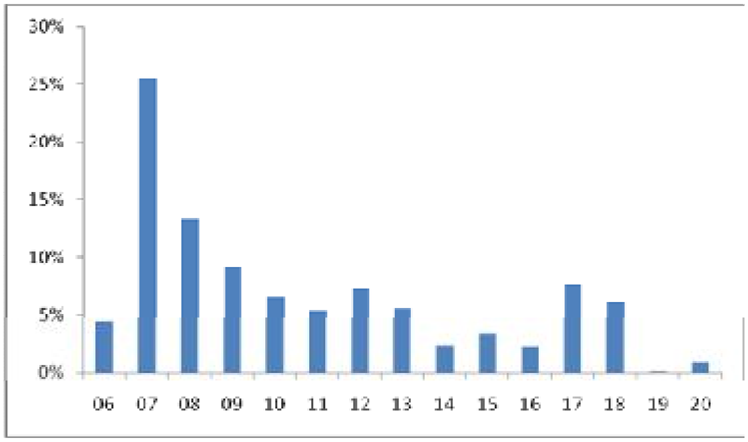

Figure 7. Circadian dynamics of flying geese through the Project area (as registered by the radar).

It was also apparent that the peak of flight activity occurred early in the day, as geese arrived from their nocturnal roost sites, with a much smaller secondary peak in the late afternoon, as birds flew back to roost sites (Fig. 7). The smaller 'departure' peak infers that geese took different routes when returning to roost.

Number of flights through the wind park territory

For the precise evaluation of the number of flights through the Project area the radar data were combined with the information of visual identification of geese species. The obtained number of flights was evaluated in respect of the species abundance and their proportions in the total number of geese.

Table 6. Total number of flights through the Project area by 5 day periods (registered by the radar).

Period	Total number of flights	Percentage RBG, based on Tables 1,2,3,and 5	Number of RBG flights
14.12.2009 - 18.12.2009	0	0	0
19.12.2009 - 23.12.2009	0	0	0
24.12.2009 - 28.12.2009	0	0	0
29.12.2009 - 02.1.2010	6480	0	0
03.1.2010 - 07.1.2010	48660	1	486
08.1.2010 - 12.1.2010	18530	1	185
13.1.2010 - 17.1.2010	3110	4	124
18.1.2010 - 22.1.2010	34630	4	1385
23.1.2010 - 27.1.2010	10970	45	4934
28.1.2010 - 01.2.2010	15260	45	6867
02.2.2010 - 06.2.2010	19570	35	6849
07.2.2010 - 11.2.2010	17050	35	612
12.2.2010 - 16.2.2010	60450	15	9067
17.2.2010 - 21.2.2010	6680	0	0
22.2.2010 - 26.2.2010	8050	0	0
27.2.2010 - 01.3.2010	9740	0	0
Grand Total	296420		30509

COLLISION RISK ASSESSMENT

In this section the results from the estimations of flight activity of geese derived by the field survey are used in a collision risk model (CRM: Band 2001, Band et al. 2007) to provide predicted estimates of the numbers of geese that may collide with operational turbine blades in SNWF. Whenever possible, the model has been run using the same parameter values as described in the 2008/09 winter report in order to provide comparable results for the 2009/10 winter.

Input data

While GWFG (*A. albifrons*) is not considered to be of conservation concern, unlike RBG (*B. ruficollis*), models were run for both species as the comparison should be both instructive and helpful in the context of determining an appropriate threshold for TSS.

Bird size and flight speed

Measures of body size were taken from Cramp (1998) and flight speed from Campbell & Lack (1985) and Provan & Whitfield (2007) (Table 7).

Table 7. Measures of goose body size and flight speed used in the CRMs.

Measure	RBG	GWFG
Body length (m)	0.55	0.72
Wingspan (m)	1.26	1.49
Flight speed (m/s)	19	19

Wind farm parameters

Input values for parameters relevant to the wind farm specifications are given in Table 8. Note that the proportion of time that turbines were assumed to be operational accounts for ‘downtime’ when blades do not turn due to wind speed and turbine maintenance. The value used in the CRMs is the standard metric calculated by the wind energy industry for modern turbines such as those deployed at SNWF.

Table 8. Input values for wind farm parameters.

Measure	Value	Notes
Number of turbines	52	
Proportion time operational	0.87	Standard industry metric
Rotor diameter (m)	90	Vestas V90 3 MW model
Rotational speed (rpm)	16.1	Variable, but 16.1 nominal speed
Maximum chord (m)	3.5	Vestas V90 3 MW model
Pitch (degrees)	15	Vestas V90 3 MW model
Corridor width (m)	6900	Mean distance across wind farm + 200 m buffer

Goose flight activity parameters

As noted above (Table 6) there were an estimated 30,509 flights of RBG through the Project area. From Table 6, for all geese there were an estimated 296,420 flights, and so after accounting for RBG (30,509 flights) and Greylag Goose (153 flights), there were an estimated 265,758 GWFG flights.

With a turbine hub height of 105 m and a rotor diameter of 90 m, the rotor swept height (RSH) which presented a risk of collision was 60 – 150 m. Since there was no marked observed species difference in flight altitude (unsurprising as mixed species flocks were the norm) the proportion of flights at risk height was taken from the more precise radar records. As a conservative (precautionary) measure of flight activity at RSH from the recorded flight heights, the data for the height band 50 – 149 m was employed, giving a value of 0.61 (61 %: Table 4).

Probability of collision

As described by Band (2001) and Band et al (2007) even if birds fly through spinning rotor blades they will not always be hit by a blade due to the interaction between the movement and metrics of the blades and the movement and metrics of the bird. This 'probability of collision' consequently varies according to blade and bird metrics and is calculated using a standard Excel spreadsheet (Band 2001). In the present study the collision probabilities were 8.1 % (RBG) and 9.0 % (GWFG).

Avoidance rate

As noted in the 2008/09 winter report, the CRM requires the application of a substantial correction factor in order to produce realistic estimates of bird fatality rates. This factor attempts to account for the fact that birds do not simply fly towards rotating blades (as assumed by the unadjusted CRM) but take action to avoid collision, and hence is called the 'avoidance rate'. As also noted by the 2008/09 winter report, a precautionary avoidance rate for geese recommended by Scottish Natural Heritage (SNH) is 99 %, based on the study by Fernley et al (2006). This was the value used in the 2008/09 winter report. However, Fernley et al (2006) recommended that a more appropriate precautionary value should be 99.6 %, and estimated that a value in excess of 99.9 % provided a more realistic empirical measure. Consequently, CRMs were run using three avoidance rates: 99 %, 99.6 % and 99.9 %.

Model outputs

Predictions based on 2009/10 flight activity

From the observed flight activity levels in the 2009/10 winter, predictions of the CRMs on the estimated number of collision strike victims varied, according to assumed avoidance rate, from about 1 – 9 for RBG and about 9 – 86 for GWFG (Table 9). As expected from their relative abundance, the model outputs predicted about 10 times more GWFG would be killed.

Table 9. Predicted annual number of geese killed by collision at SNWF based on observed flight activity in the 2009/10 winter, under three CRM avoidance rates.

Species	Avoidance rate		
	99 %	99.6 %	99.9 %
RBG	8.9	3.6	0.9
GWFG	86.1	34.4	8.6

Comparison with 2008/09 results

Before comparing the results from the two winters it is necessary to clear up a discrepancy in the 2008/09 winter report. The 2008/09 winter report presented results only for RBG using a 99 % avoidance rate. There is some potential confusion in documentation of a key input value in the 2008/09 winter report, the number of flights through the Project area. In the Collision Risk Assessment section (P. 42) it notes that the number of RBG flights was taken as being 90,000 for dawn and dusk and with an assumed additional 15 % to allow for unrecorded flights that may have occurred in the middle of the day. This gives a total number of flights as

103,500. However, elsewhere in the report (P. 39) it states that there were an estimated 65,000 RBG flights through the Project area in the winter.

Running both these values through a CRM with a 99 % avoidance rate, attempting to keep all other parameter values the same as those given by the 2008/09 winter report (although not all employed values are presented in the report) gave estimated RBG annual fatality rates of 23.6 and 86.1 deaths for 65,000 and 103,500 flights respectively. As the reported figure in the 2008/09 report was 22 deaths, and acknowledging that some input measures could not be replicated exactly (as they were not presented in the 2008/09 winter report) the obvious conclusion is that despite what is stated in the Collision Risk Assessment section of the report, a value of 65,000 flights (and not 103,500) was used in the 2008/09 CRM.

With this understanding, the CRM results for RBG for 2009/10 still contrast markedly with those from 2008/09 in that predicted fatalities are less than half in 2009/10 – obviously the reduced number of RBG flights through the Project area in 2009/10 is the predominant influence. At this stage it is difficult to be sure as to why there was this difference in the number of estimated flights, although there are several possibilities, such as:

- Availability of feeding opportunities in the Project area differed through differences in crop rotation or snow cover;
- RBG showed some reluctance in 2009/10 to enter a fully constructed (and, through testing, partially operational) wind farm;
- There were few ‘real’ differences between winters, but through deployment of the radar and concentration of observation effort on the Project area, the 2009/10 study had to make fewer assumptions and so the data were more ‘realistic’.

It is likely that several of these possibilities were influential in some way, although a key consideration is that although the severity of winter conditions seems to have a positive influence on RBG occurrence in the region, the 2009/10 was relatively cold compared to recent winters and so more RBG should have been expected (i.e. in contrast to the records of goose activity in the Project area contrasting the two previous recent winters). The numbers of geese present in 2009/10 was close to the maximum recorded in any winter (P. Zehtindjiev unpubl. data). Moreover, there has also been speculation that the use of the Black Sea as a roost site by geese may increase goose occurrence and, therefore collision risk, within the Project area. This potential factor can be dismissed as influential because such behaviour was not observed in 2008/09 but was observed in 2009/10 (Fig. 3).

On balance, one of the most likely reasons for the discrepancy in predicted RBG collision fatality between the two winters probably lies in the improved 2009/10 methods to document goose flight activity.

Implications of the predicted collision fatality rates

The threshold employed by the 2008/09 winter report (and EMMP) for a ‘significant effect’ of RBG fatality was deemed as being “1% increase over the existing baseline mortality”, and refers to SNH/BWEA (2002) assessment methodology as its basis. Not only is this reference spurious (SNH do <u>not</u> employ this measure as a threshold for a significant effect) but, as documented in detail by Whitfield (2010), it can be disputed on assumed measures of ‘background mortality’ and should also be rejected on ecological and conservation grounds. Whitfield (2010) highlighted that more appropriate information on RBG ecology and the effects of SNWF on the species should be collated in order to provide a more appropriate threshold on significance of effect.

However, even if this flawed threshold is accepted as being the current criterion for acceptability of SNWF's ornithological impacts (and as a trigger for mitigation such as TSS) then clearly the (more accurate) results from the 2009/10 season show that predictions fall well-short of the threshold in terms of necessity for mitigation including, primarily, the TSS. The implication of the "1% increase over the existing baseline mortality" threshold is that SNWF should not kill more than 31 RBG per year (Whitfield 2010). The results from the 2009/10 analyses suggest that the predicted annual number of RBG deaths lies in the range of 1 – 9; well short of this threshold and well short of any need to instigate mitigation measures such as the TSS. Clearly for the threshold to be breached there would need to be over three times and up to 30 times more RBG flights passing through the Project area at RSH.

The assessment predicted that there should be about 10 times more GWFG killed than RBG. This ratio was probably similar in the 2008/09 winter (P. 38, 41 in 2008/09 winter report). This finding, due largely to the relative abundance of the two species, can allow further refinement of future assessments (notably the most appropriate avoidance rate) and incorporation into a trigger for the TSS. Monitoring of collision victims of GWFG (as well as RBG) will provide an early warning system in that for about every one RBG killed we should expect about ten GWFG killed, and so an indication of likely RBG mortality can be judged well before reaching potentially problematic levels, by monitoring GWFG deaths.

Systematic searches for collision victims were not conducted for the 2009/10 winter (but are planned for the 2010/11 winter). However, there were no reports or observations of collisions, despite several thousands of recorded flights, the geese apparently navigating through or over the wind turbines with ease, and regular visits by technicians to the turbines found no dead birds. While subjective, the observations did not contradict the conclusion that the Project does not have the potential to have an adverse impact upon the RBG population, and that the 'realistic' CRM predictions are more likely to be in the lower range of estimates (i.e. avoidance rates should be about 99.9 % or higher).

CONCLUSIONS

The methods applied to this study have provided important information concerning the species composition of geese and their spatial and temporal distribution within the Project area. Furthermore, the number of observation points and the sample size collected is representative for the whole population of the wintering geese in the Project area. Deployment of radar and its incorporation into the survey protocols provided a major advantage and increased quantification of results.

The wintering period of the geese started in the middle of December and ceased by the end of February, as observed in 2008/2009 winter. Three goose species were recorded: RBG, GWFG and Greylag Goose. GWFG was the most common species recorded, and the percentage of occurrence of RBG varied between 0 % and 20 % during the season, on average about 10 %; again similar to the 2008/2009 winter. Greylag Goose was recorded sporadically and in small numbers and was not therefore considered at risk from the project. The duration of the winter stay in the study area was similar for both RBG and GWFG. However, there was a definite ‘peak’ period of activity with a concentration of over 90% of RBG being seen within 20 days; which corresponded to the coldest period of the winter.

The flight altitudes of the geese from all species observed crossing the Project area were most intensive between 50 and 100 m above the ground level. Diurnal activity of the geese generally indicated two periods of intensive movements/flights: morning (7-9h) and, to a lesser extent, evening (16-18h). These findings were also similar in the 2008/2009 winter.

The results of the Collision Risk Assessment in 2008/2009 was based on an assumption of over 65,000 flights of RBG through the Project area and predicted 22 RBG collisions per year, applying a precautionary 99% avoidance rate. This prediction fell short of the threshold number of collisions (31) that would need to occur to result in a significant impact (i.e. to exceed a negligible magnitude effect, defined as a 1% increase over the existing baseline mortality) (see winter survey report 2008/2009). While this threshold criterion is flawed and requires replacement with a more appropriate alternative, in the interim it follows the EMMP.

The number of RBG flights (30,500 flights detected by the radar) during the 2009/2010 winter, when used in a Collision Risk Assessment, gave a predicted 1 – 9 RBG annual collisions (the range given by different assumed avoidance rates). This result suggests that the Project does not have the potential to have an adverse impact upon the RBG population as there would need to be 3 – 30 times more RBG flights than observed in 2009/2010, which seems highly unlikely given that the 2009/10 winter was especially cold and so geese numbers were high. Subjective records of collisions with operational turbines were consistent with this conclusion, and that the lower mortality estimates from collision risk modelling are probably the most realistic.

A contributory explanatory factor to the differing predictions between the two winters, despite several other similarities, is likely to be the improved survey methods employed in the 2009/2010 winter study. Use of the Black Sea as a roost site by geese was observed in the 2009/2010 winter but not the 2008/2009 winter. Hence, while it had been previously suggested that such behaviour could increase collision risk, the 2009/2010 results suggest that this is not the case.

Analyses indicated that the wind farm should kill about 10 times more GWFG than RBG and this, as well as expectations of the number of RBG flights necessary to be problematic, will allow further refinement of protocols necessary to implement a TSS.

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