Bird migration monitoring in the AES Geo Power Wind Park territory, Kaliakra region, in autumn 2012, and analysis of potential impact after three years' operation

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Contents

SUMMARY

1. This report presents the comparative results of five autumn seasons' study of birds at the St Nikola Wind Farm (SNWF), with a special focus on the possible impact of SNWF on migrating birds.
2. Spatial and temporal dynamics in the numbers of different species passing through the wind park territory during autumn migration 2012 (15 August to 30 September) are presented.
3. The data gathered from visual observations are analysed.
4. The data from the autumn monitoring in 2008, 2009, 2010, 2011 and 2012 are used to test the potential change in species composition, numbers, altitude or the flight direction of passing birds in autumn, as a result of SNWF's presence.
5. The variations in numbers of species, absolute number of birds, overall altitudes of flight and migratory direction do not indicate an adverse effect of the wind farm on diurnal migrating birds.
6. The Turbine Shutdown System probably contributed to a reduced risk of collision during all years of operation within infrequent periods of intensive soaring bird migration and provided a safety mechanism to reduce collision risk for both single birds of endangered target bird species and/or flocks passing through the wind park territory.
7. The low number of victims of collision found in four autumn seasons in systematic 7 day (or less) interval searches for casualties under every turbine does not provide evidence for additional mortality caused by SNWF as a threat to populations of any bird species migrating through the territory.
8. The data to date indicate that SNWF does not constitute a major obstacle or threat, either physically or demographically, to important populations of diurnal autumn migrants.

INTRODUCTION

In NE Bulgaria, close to the Black Sea coast, AES Geo Energy OOD constructed a 156 MW wind farm consisting of 52 turbines in 2009: the St Nikola Wind Farm (SNWF). In autumn 2008, SNWF did not exist; in autumn 2009 the facility was built but not operational (i.e. turbine blades were not moving), and in the autumns of 2010 and 2011 SNWF was operational. In the last eight years, several field studies have investigated the spatial and temporal distribution of the migratory and the breeding birds within this area. The main results of the autumn monitoring of bird migration in the vicinity of SNWF in previous years are published at: http://www.aesgeoenergy.com/site/Studies.html. In these studies no collision mortality of migrating birds was found indicating a high avoidance rate of the turbines by migrating bird species. On the other hand, strong fluctuations in numbers of different species were correlated significantly with the wind direction especially when westerly winds occur in the peak of soaring bird migration period. It was evident that SNWF does not lie on the main migration route of the Via Pontica (likely because of its proximity to the Black Sea and that it is on a cape, at Kaliakra) and only receives major migratory ‘traffic’ when (unusual) westerly winds push birds from the main route (Figure 1).

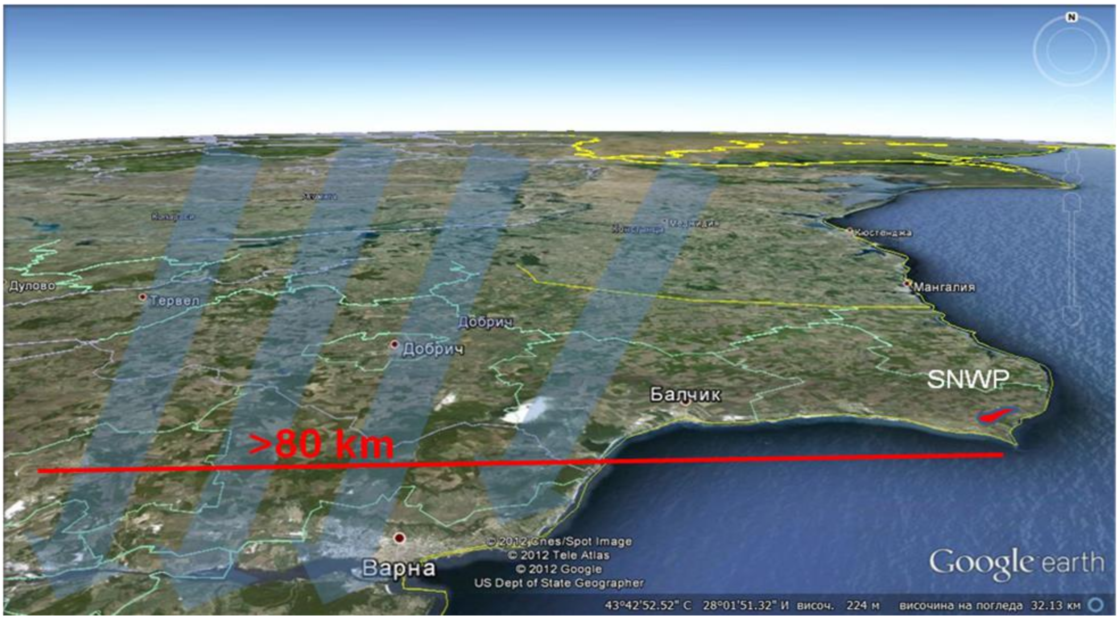


Figure 1. Schematic representation of the main autumnal migratory flyway - the Via Pontica (blue arrows), and the location of SNWP (SNWF) territory in red.

In the previous 2011 autumn report the major question addressed was whether SNWF potentially has a barrier effect on birds migrating through the territory. The analysis of the data until autumn 2011 showed no evidence for cumulative long term changes in the migratory bird fauna.

The present report updates the information on spatial distribution and temporal presence of observed species in autumn 2012 in the wind park territory as well as the efficiency of the applied - for the third year - Turbine Shutdown System (TSS) for the reduction of collision risk.

METHODS

The study area

SNWF is located in NE Bulgaria, close to the Black Sea coast near the cape of Kaliakra. The wind farm lies between the road from the village of Bulgarevo to St. Nikola (municipality of Kavarna), and the 1st class road E 87 Kavarna – Shabla, as shown in previous reports (and in Fig. 2). SNWF consists mainly of arable land with different crops (wheat, sunflower, rapeseed), intercepted with roads and wooded shelter belts. The development area is outside the NATURA 2000 site “Kaliakra”.

Study duration and equipment

The study was carried out in the period 15 August – 30 September 2012 in the same study period as in 2008 - 2011, covering a total of 45 days: the period of the most intensive migration. The surveys were made during the day, in a standard interval of time between 8 AM and 6 PM Astronomic time.

Radar observations were made permanently during the day time and for 15 minutes per every hour of the night (20 h – 05 h) during the whole period of the survey in 2012 according to the following scanning program:

Diurnal Radar Observations

1. Four minutes at 30 mills, or as low as ground clutter permits (equivalent to approximately 25-275 m elevation at 5 km distance);
2. Four minutes at 80 mills (equivalent to 275-525 m at 5 km distance);
3. Four minutes at 130 mills (equivalent to 525-775 m at 5 km distance);
4. Four minutes at 180 mills (equivalent to 775-1025 m at 5 km distance);
5. The magnetron then rested for one minute, and then the cycle was recommenced.

Nocturnal Radar Observations

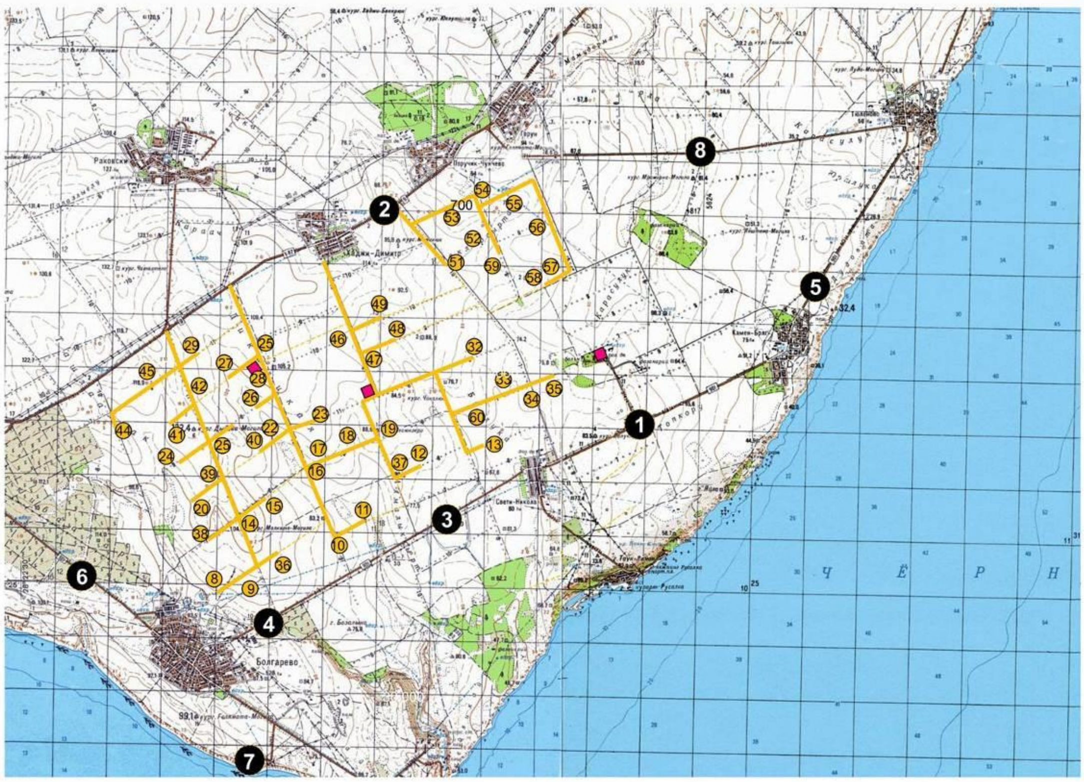
1. Four minutes at 30 mills; (equivalent to approximately 25-275 m elevation at 5 km distance);
2. Four minutes at 150 mills (equivalent to 675-825 m at 5 km distance);
3. Four minutes at 700 mills (equivalent to 3375-3625 m at 5 km distance);
4. The magnetron then rested for 48 minutes, and then the cycle was recommenced.

Visual observations were used in the analysis and comparison of different years and changes in absolute numbers of birds, altitudes of flight and directional distributions, to maintain consistency across years of study. The radar data can, nevertheless, have a number of analytical applications as regards cross-checking of visual records and their accumulation can allow further analyses e.g. they will be analysed in respect to the nocturnal migration under request of AES Geo Energy. The radar was also applied in the collision risk reduction system for correct estimation of altitude of the flocks passing through the wind park territory.

Basic Visual Observation Protocol

The study in autumn 2012 involved direct visual survey of all passing birds from several observation points (Figure 2). Field observations followed the census techniques according to Bibby et al. (1992). Point counts were performed by scanning the sky in all directions. Height estimates and distances to the birds were verified with land mark constructions around the observation points prevously measured and calibrated by GPS. The surveys were carried out by means of optics, every surveyor having a pair of 10x binoculars and all observation points were equipped with 20 – 60x telescope, compass, GPS, and digital camera.

Figure 2. Locations of the wind farm turbines (numbered yellow dots), radar beam and the observation points (numbered black dots). The location of the radar and its scan was the same as in 2010 (see http://www.aesgeoenergy.com/site/Studies.html).



All observations during period of autumn migration 2008 – 2012 birds are involved in the present comparative analysis. The basic protocol is unlikely to have made a major difference in the records collected between years because the observation effort was capable of coping with the volume of avian migratory traffic, and no observer was ‘swamped’ in time under the circumstances outlined by Madders and Whitfield (2006).

All observers were qualified specialists in carrying out the surveys of bird migration for many years including previous autumn surveys at SNWF. Some of the observers are active members of the BSPB (BirdLife Bulgaria).

List of participants in the observations, 2012:

Dr Pavel Zehtindjiev
Institute of Zoology
Bulgarian Academy of Sciences
Senior Field Ornithologist

Victor Metodiev Vasilev
Senior researcher in the Faculty of Biology
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Member of BSPB since 1992

Dr Dimitar Vladimirov Dimitrov
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Ivailo Antonov Raykov
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Strahil Georgiev Peev
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Karina Ivanova
Student in Faculty of Biology
Sofia University

MSc Martin Petrov Marinov
PhD student in Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences

Specific Visual Observation Protocol

During the visual surveys the following records of flying birds were noted by observers:

- Species and (if possible) gender and/or age;
- Number;
- Distance from observer;
- Direction from the observation point;
- Altitude;
- Direction of flight (flight path);
- Behaviour (notably flight behaviour) concerning existing wind farm constructions;
- Supplementary behavioural observations;
- Weather conditions;
- Precise position of birds simultaneously registered at the radar screen and by observers birds were recorded in order to ascribe specific echo signatures of target species (i.e. Pelicans, Storks and Raptors) to known species.

Species

All soaring birds, flying in the surveyors' scope of view were identified to the level of species, if possible, and recorded. The characteristics of gender (male or female) and age (adult, subadult, immature, juvenile) were also recorded for certain species when conditions allowed. Because of the difficulty in distinguishing between similar species in harsh conditions (e.g. bad visibility, great distance, etc.), if exact identification was not possible both possible species were recorded (e.g. *Aquila pomarina / clanga* or *Aquila clanga / pomarina*, depending on which of the two species was more probable). In certain cases when it was not possible to identify the bird of prey species, the bird was recorded to the lowest possible taxonomic category (e.g. genus, e.g. *Circus sp.*). When conditions did not allow identification of a bird of prey to a lower taxonomic category it was recorded as NBP (non-identified bird of prey).

Number (abundance)

The surveyors counted all migrating soaring birds, flying in their scope of view, regardless of the possibility to distinguish their species or higher taxonomic category (as described in the previous point). When the data were recorded, single birds (or pairs), as well as discrete flocks, were noted along with their number and species composition. In the case of larger flocks (e.g. white stork), when the counting of every single individual was impossible, birds were counted in groups of 5 or 10 birds after the flock started planing to the next thermal.
For the comparative analysis of the numbers data from constant observation points were used.

Distance (horizontal and vertical) of the flying flocks and single birds' trajectories

Along with counting migrant soaring birds, recording the spatial location and flight trajectories of migrants was among the most important tasks of the study. The distance from the observation point and flight altitude was noted for each bird or flock.

Recording flight height estimates and distances to birds was assisted by reference to land marks near the observation points which had been previously measured and calibrated using GPS. Additionally, all human visual observers and radar observations were tested before observations commenced in a series of trials using a GPS device attached to a kite, flown at various heights and distances (Photo 1 in Autumn Monitoring Report for 2009). In each trial, the kite was independently observed (i.e. the kite controller and observer were independent) with height and distance recorded by the observer. These records were then compared with data on height and distance from the GPS device attached to the kite during the same trial. Differences between the 'observed' (human) records and the 'true' (GPS) records were then used to calibrate subsequent estimates for any consistent biases in records of birds observed during migration. The radar data, with precise measurements of distances and altitudes, were also used for the calibration of visually estimated altitudes of soaring migrants.

Flight direction

Flight direction was recorded as the geographic direction on which the bird or flock was heading relative to the observation point. To facilitate definition of the flight direction a geographic compass and GPS device was provided for every observation point. Direction was defined whenever possible on an exact compass bearing or, for a dispersed flock, as one of 16 possible sectors of the geographic compass (every sector being limited to 22.5 degrees), as follows: N (north), NNE (north-northeast), NE (northeast), ENE (east – northeast), E (east), ESE (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). In the database flight direction of the bird was transcribed in degrees as a mean angle of the sector.

Weather conditions

Weather is an obvious potential influence on bird migration and the capacity to record birds visually. Hence, the following measures were recorded:

- Wind direction;
- Wind strength;
- Air temperature;
- Cloud cover;
- Rainfall;
- Visibility.

The direction and strength of the wind as well as temperature were precisely measured by the AES Geo Energy meteorological masts and kindly offered for analysis. Cloud cover was recorded as the relative cover (in %) of the visible part of the sky. Visibility was taken as the maximum distance at which permanent geographic landmarks could be seen, defined and recorded in metres

Weather records were made every morning at the start of the surveys, at every full hour subsequently, and when surveys stopped in the evening, as well as at any time when a considerable change in visibility occurred due to factors like fog or mist. The presence of factors, like fog, mist and other phenomena deteriorating the visibility was also taken into account in analysis.

Recording of the data

All the data of the surveys were entered in a diary. The data were processed daily and transcribed to a database designed in an Excel workbook. The protocol of primary data processing is 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).

The diary was kept in the following manner:

1. In the morning, with the start of the surveys, the date and the exact time 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 values of the physical factors of the environment (weather conditions, as described above) and the names of the surveyors.
2. When observing a migrating bird or flock, first the exact time was taken down, the species, genus or family Latin name, (gender and age, if possible), then the numbers, the vertical and horizontal distance from the watch point, the flight direction. After these obligatory data, additional ones, like soaring, "chimney" formation of flocks, landing birds with the exact location of landing, etc., were also recorded.

   Meanwhile, if changes in the weather or other interesting and/or important phenomena should be registered, they were also entered in the diary with the exact time of the observation.
3. In the evening, when finishing the surveys, the exact time, weather conditions and the names of the surveyors were taken down again.

Collision Victim Monitoring

The collision monitoring methodology followed that developed in the USA for bird collision monitoring at wind farms (Morrison 1998). The detailed description of the protocol is given in the Owners Ornithological Plan. Results of the monitoring were reported to the Regional Inspectorate of the Bulgarian Ministry of Environment and Waters in Varna every month during the first year of the operation. A final report has been prepared based on the results of the monitoring after one year operation period of the wind park (March 2011).

It is well known that searches for victims of collision with operational wind turbines fail to find all dead birds, for several reasons, with the two principal factors being searcher efficiency (searchers fail to find all dead birds) and removal/disappearance of dead birds before the searcher can potentially find them. Accounting for these two potential biases can substantially improve estimates of collision mortality at operational wind farms derived from searches around turbine bases. As described, in number of reports, trials were undertaken in order to provide for such correction (see details in own ornithological plan at: http://www.aesgeoenergy.com/site/Studies.html.)

An important objective of the trials was to examine the frequency of the searches concerning efficiency for collision victims, calibrated for the removal rate of carcasses and check that the search interval protocol for collision victims proposed by the EMMP (7 days apart, at every turbine) was appropriate. The 2009 and 2010 trials during autumn were similar in their results and confirmed that the adopted protocol of a seven day search interval during autumn migration will detect about half of all collision victims of medium to large species (i.e. those species which are of primary conservation concern at SNWF during autumn: migrating raptors, storks, and pelicans).

Statistical methods

The number of observed species, individuals as well as their average altitude of flight (by species and years) is presented in number of tables for direct comparision of the seasons of 2008 - 2012.

The altitude of migration in different seasons was evaluated for significance by its mean value, standard error and standard deviation in data analysis software system

STATISTICA (StatSoft, Inc. (2004, version 7. www.statsoft.com.). The mean flight direction as well as its significance level, for every species and group of species was calculated according to standard circular statistics (Batschelet 1981). Circular statistics was performed by Oriana (Oriana - Copyright © 1994-2009 Kovach Computing Services). This program allows comparing two or more sets of circular distributions (directions) to determine if they differ. The tests were performed as pairwise, where each pair of samples is compared.

Many of the basic statistical parameters are based on the concept of the mean vector. A group of observations (or individual vectors) have a mean vector that can be calculated by combining each of the individual vectors (the calculations are explained in most books about circular statistics). The mean vector will have two properties; its direction (the mean angle, **μ**) and its length (often referred to using the letter **r**). The length will range from 0 to 1; a larger r value indicates that the observations are clustered more closely around the mean than a lower one. Details about the Oriana software and statistical test used are available at: http://www.kovcomp.com/

Turbine Shutdown System

The general principles, which provide a procedural checklist, were previously described in autumn report 2010 (http://www.aesgeoenergy.com/site/Studies.html). It should be noted that, due to the complexity of possible combinations of conditions that may be experienced on site, the principles are not scenario based (i.e. the potential number of scenarios, when considering all species and circumstances at any one time, would be too numerous to prescribe).

The TSS protocol was followed in order to reduce risk during the period of intensive migration in autumn 2012 between 15 August and 30 September. Turbine shutdowns are ordered by the Senior Field Ornithologist or -when delegated to- field ornithologists in case of any perceived risk, such risk as per the discretion of the ornithologist.

RESULTS

Composition of species and number of birds passing through the wind park territory

The occurrence of species across all years is presented in Table 1. A total of 113 bird species have been observed in the wind park territory during the five consecutive autumn seasons of 2008, 2009, 2010, 2011 and 2012. The number of all observed species varied from 48 to 79 in different years. Most species (79) were observed in 2009 and 2012, the year when the wind park had been constructed and in the third autumn after construction, respectively. There is no significant difference in the number of species observed in 2008 (before the construction of the wind park) and during the later period when the wind farm was present (2009 – 2012).

Table 1. List of species observed in the wind park territory during period 15th August – 30th September in preconstruction (2008) and postconstruction (2009, 2010, 2011 and 2012 in grey) periods of SNWF. Hatched cells represent the years when the species was registered in SNWF territory.

Species	2008	2009	2010	2011	2012
A. apus	X	X	X	X	X
A. arvensis		X			X
A. brevipes	X	X	X	X	X
A. campestris		X			X
A. cervinus					X
A. chrysaetos			X	X	X
A. cinerea	X	X	X	X	X
A. gentilis	X	X	X	X	X
A. heliaca	X				
A. melba	X	X	X	X	X
A. nisus	X	X	X	X	X
A. pennata	X	X	X	X	X
A. pomarina	X	X	X	X	X
A. pratensis					X
A. purpurea	X	X	X	X	X
A. trivialis	X			X	
B. buteo	X	X	X	X	X
B. oedicnemus		X		X	
B. rufinus	X	X	X	X	X
B. vulpinus					X
C. aeruginosus	X	X	X	X	X

Species	2008	2009	2010	2011	2012
C. cannabina					
C. canorus					
C. carduelis					
C. chloris					
C. ciconia					
C. coccothraustes					
C. corax					
C. cornix					
C. coturnix					
C. cyaneus					
C. frugilegus					
C. gallicus					
C. garrulus					
C. livia domestica					
C. macrourus					
C. monedula					
C. nigra					
C. olor					
C. palumbus					
C. pygargus					
D. major					
D. urbica					
E. alba					
E. calandra					
E. garzetta					
E. hortulana					
F. cherrug					
F. coelebs					
F. eleonorae					
F. naumanni					
F. parva					
F. peregrinus					
F. subbuteo					
F. tinnunculus					
F. vespertinus					
G. fulvus					
G. glandarius					
H. daurica					
H. icterina					
H. pallida					
H. rustica					
J. torquila					
L. cachinnans					

Species	2008	2009	2010	2011	2012
L. collurio					
L. megarhynchos					
L. melanocephalus					
L. minor					
L. ridibundus					
M. alba					
M. apiaster					
M. calandra					
M. cinerea					
M. flava					
M. migrans					
M. milvus					
M. striata					
N. percnopterus					
O. hispanica					
O. isabellina					
O. oenanthe					
O. oriolus					
O. pleschanka					
P. apivorus					
P. caeruleus					
P. crispus					
P. haliaetus					
P. leucorodia					
P. major					
P. montanus					
P. onocrotalus					
P. perdix					
P. pica					
P. viridis					
Ph. carbo					
Ph. collybita					
Ph. trochilus					
Pl. falcinellus					
R. riparia					
S. borin					
S. communis					
S. curruca					
S. rubetra					
S. vulgaris					
St. hirundo					
Str. decaocto					
Str. turtur					

Species	2008	2009	2010	2011	2012
T. nebularia					
T. tadorna					
Tr. ochropus					
U. epops					
V. vanellus					
Ph. ochrurus					
Ph. phoenicurus					
Number of species	76	79	48	71	79

Most variations in the species observed by year were due to single observations of rare bird species or small passerine birds whose registration in open agricultural fields was highly dependent on the location of observation points and surrounding vegetation. Such observations do not allow quantitative analysis of the data becouse of the low sample sizes involved.

25 species were observed only one year, 22 species were observed in two years and 19 species were observed in three years. Only 11 species were observed every autumn season in the period 2008 – 2012. Among the irregularly recorded bird species, seven were observed in 2008 before the construction and did not appear in any of the autumns after construction of SNWF. Four passerine birds: *M. cinerea*, *H. icterina*, *H. pallida* and *C. corax* were observed only in 2008. The first three of these are small forest birds and open habitats of agricultural fields are not their preferred habitat. The common raven *C. corax* is a non migratory species primarily found in mountainous regions. The number of this species in Bulgaria has gradually increased in recent years and its appearance in SNWF territory can be considered as a result of dispersal. Anyway, none of these species can be considered as endangered or limited by the SNWF construction and therefore their appearance only in 2008 is probably a matter of rarity in the region and vagrancy, and not an effect of construction.

Three soaring bird species: *A. heliaca*, *P. crispus, F. naumanni* were also registered as two, three and one individuals, respectively, only in autumn 2008. All three species are rare in general and these sporadic observations are probably unrelated to SNWF preconstruction and postconstruction periods. By contrast, another 27 species of birds were not recorded in 2008, but observed in the postcostruction period. Among such species were, for example, many birds of prey like *A. chrysaetos, F. cherrug, M.*

milvus; waders like *V. vanellus*, *Tr. ochropus*, *Tr. nebularia*, *B. oedicnemus*; herons like *A. purpurea*, *E. alba*, *E. garzetta*; and many small passerine bird species. The occurrence of these species after construction should probably not be attributed to any beneficial effect of SNWF's presence, but (again) to vagrancy.

Two vulture species were also registered only after construction of SNWF. Both species are not present in any available literature concerning the region including standard forms of nearest NATURA 2000 zones. Griffon vulture (*Gyps fulvus*) was observed in autumn 2010 and 2012. This species does not qualify as threatened, near threatened, or conservation dependent according to IUCN and is in the category as least concern; but it is a rare species in Bulgaria. A number of individuals of this species are currently being introduced to Bulgaria from Spain and the Bulgarian population is increasing in number. The griffon vulture observed in autumn 2012 (Fig. 3) was identified after exchange of information with conservation organizations working on reintroduction of the species in Bulgaria as an individual ringed in Croatia (Cres Island on 9th of May 2012). In autumn 2012 the same individual was observed on three dates in the SNWF territory (15th September, 20th September and 22nd September), mostly flying around the coast but including a crossing of the wind farm on the first date.

The Egyptian vulture (*Neophron percnopterus*) is an Endangered (IUCN 3.1)[1] species observed for the first time in autumn 2012, on 7th September, making a flying circuit close to the coast of the cape between the wind farm and the Black Sea. This species is widely distributed from southwestern Europe and northern Africa to India. Populations of this species have declined in the 20th century and some island populations are endangered by hunting, accidental poisoning, and collision with power lines. The Egyptian vulture observed near SNWF in autumn 2012 was equipped with satellite transmitter. Immediate exchange of information with the field team of the LIFE + project "Urgent measures to secure the survival of the Egyptian vulture (*Neophron percnopterus*) in Bulgaria and Greece" allowed identification of the bird as a juvenile from a nest near Beloslav (Varna district).

Figure 3. Griffon Vulture observed in the region of Kaliakra in September 2012 (Photographs courtesy of Robert Carr, UK).

These isolated observations do not allow an estimation of any changes in the number of birds, flight charachteristics or behavior and we can only say that the listed species are not typical for the region in autumn migration as they were observed only occasionally during the period of the study (2008 – 2012). As such species are uncommon in the study area then any impact, including a barrier effect, will clearly be immaterial in its consequences on populations, even if it occurs.

Absolute numbers of soaring species which were most numerous, together with some additional species with high conservation value are presented in Table 2.

Table 2. Numbers of birds recorded as passing through SNWF territory (primarily soaring water birds and birds of prey) in five autumn seasons of preconstruction (2008) and postconstruction (2009 – 2012) periods.

Species	2008	2009	2010	2011	2012
A. brevipes	95	210	976	290	94
A. chrysaetos			2	2	1
A. cinerea	120	259	26	40	56
A. gentilis	10	6	5	11	22
A. heliaca	2				
A. nisus	44	44	70	73	44
A. pennata			5	1	9
A. pomarina	44	9	80	76	31
A. purpurea		59	11	1	7
B. buteo	146	390	180	459	238
B. oedicnemus		1		1	
B. rufinus	163	151	34	30	33

Species	2008	2009	2010	2011	2012
C. aeruginosus	327	268	341	271	179
C. ciconia	2998	87	24980	620	2525
C. cyaneus	5	1		1	
C. gallicus	29	19	18	25	60
C. macrourus	8	27	18	4	7
C. nigra	8	8	8	1	13
C. olor		1	3		
C. palumbus	10		1		
C. pygargus	32	17	111	151	55
E. alba			1	1	
E. garzetta		7			
F. cherrug		7		2	1
F. eleonorae	7			1	1
F. naumanni	1				
F. peregrinus		2	4	1	
F. subbuteo	48	125	120	96	66
F. tinnunculus	138	357	45	120	67
F. vespertinus	11	180	1773	63	793
G. fulvus			1		1
H. pennatus	4	3	17	4	1
M. migrans	18	6	32	17	21

Species	2008	2009	2010	2011	2012
M. milvus			1	1	
N.percnopterus					1
P. apivorus	58	76	1549	152	115
P. crispus	4				
P. haliaetus	15	13	14	12	7
P. leucorodia	117	83	56	48	
P. onocrotalus	120	1190	252	277	1700
Ph. carbo	267	354	494	75	131
Ph.pygmaeus		19			
Pl. falcinellus	5	738			
St. hirundo		71			
T. tadorna		94			3
Tr. ochropus		8			1
V. vanellus			1		
Total	4855	4890	31229	2927	6585
Number of species	30	35	33	33	30

This result shows that the constructed wind park did not appear to change the fundamental migratory habits of the species crossing the territory. The fluctuations in soaring bird numbers were apparently highly dependent on the occurrence of western winds in the period of migration of the most numerous species, notably the white stork *C. ciconia* which can comprise 80% of all soaring migrants. The fluctuations of white storks were the most influential on overall numbers of soaring birds during the period 2008 – 2012. The numbers of all soaring bird species varied by years with no trend for decrease after the park was constructed and started its operation (Figure 4).

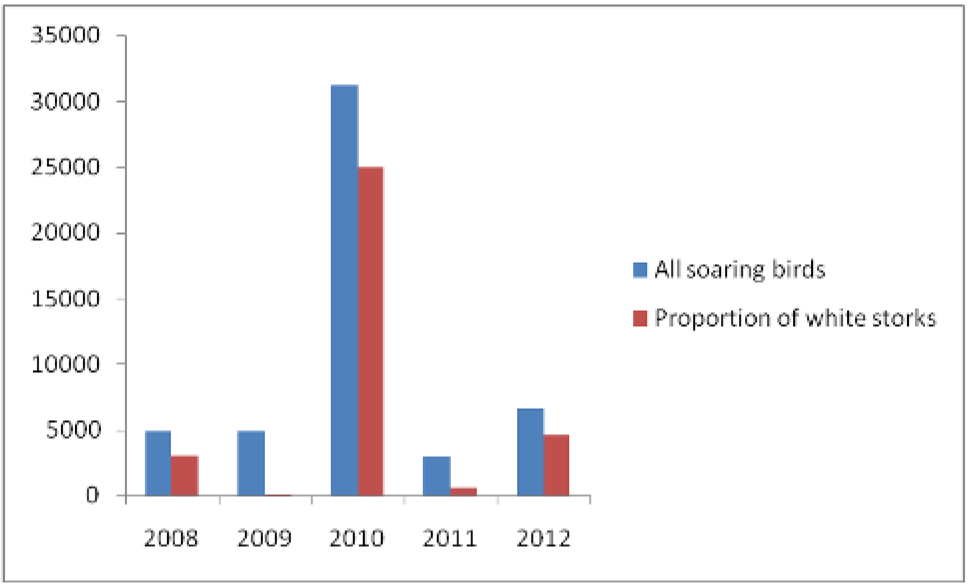


Figure 4. Variations in total number of soaring birds observed during autumn migration in five years (preconstruction and operational period) in the wind park territory.

Other species with relatively high numbers during all five years of study included in the present report were bee-eaters, swifts and swallows. The recording of these species highly depends on the distance from the observer because of the small size of the birds. Therefore visual observations on these species are limited to a few hundred metres and can not be considered as absolute numbers for a given area and at all altitudes. The results on the numbers of bee-eaters and swallows registered in the period 2008 – 2012 are given in Table 3 below.

Table 3. The number of bee-eaters, swifts and swallows in SNWF in five autumn seasons as observed in the period 15 August – 30 September.

Species	2008	2009	2010	2011	2012
A. apus	79	10	6	8	17
A. melba	515	16	536	234	47
D. urbica	1007	697		180	3

Species	2008	2009	2010	2011	2012
H. daurica	2	8		4	1
H. rustica	2979	4234	1735	164	5994
M. apiaster	4625	3355	5024	2107	2733
Grand Total	9207	8320	7301	2697	8795

Altitude of autumn migration

Because of the variations in species composition and number of different species (see previous section) as well as limitations of the visual observations as a method that is applicable mainly for registration of soaring birds, not all the observed species allow comparative analysis of the flight altitudes in long term period of five autumn seasons. Distribution of altitudes of birds recorded during autumn migration at SNWF was reported in number of reports for 2008, 2009, 2010 and 2011 available at: http://www.aesgeoenergy.com/site/Studies.html. The same species were used in order to keep a standard statistical approach in autumn 2012.

In order to test whether there has been change in altitude distribution of birds between the preconstruction and operational periods we have calculated average altitude per year of all species of diurnal migrants regularly passing through the wind park territory in autumn. The results are presented in Table 4.

Table 4. Average flight altitude, by species, of diurnal migrants observed in SNWF across five autumn seasons, 2008-2012: the years of commercial operation of the wind farm are highlighted in grey.

Species	**2008**	**2009**	**2010**	**2011**	**2012**
A. brevipes	132	171	171	160	142
A. cinerea	201	239	263	386	190
A. gentilis	181	176	230	199	151
A. nisus	150	135	162	141	119

Species	**2008**	**2009**	**2010**	**2011**	**2012**
A. pennata	150	283	251	213	295
A. pomarina	244	273	234	234	241
B. buteo	165	199	206	197	158
B. rufinus	109	200	230	183	147
C. aeruginosus	158	139	235	150	128
C. ciconia	199	174	434	347	358
C. cyaneus	136	100		10	
C. gallicus	256	144	258	242	218
C. macrourus	251	90	240	195	86
C. nigra	462	325	375	350	388
C. pygargus	196	115	285	106	79
F. subbuteo	97	119	161	161	127
F. tinnunculus	49	96	109	70	79
F. vespertinus	106	106	224	289	121
M. migrans	175	183	166	152	233
P. apivorus	320	175	268	283	204
P. haliaetus	314	208	224	433	
P. leucorodia	433	285	667	317	
P. onocrotalus	100	159	417	400	265
Ph. carbo	180	179	277	271	254
All species	157	154	246	179	156

The comparative analysis showed that birds passed higher in 2010 than in the other four autumn seasons of our study. A statistical difference was found only in average altitudes in autumn of 2010 in respect to the average altitudes of the autumn migrations in 2008 and 2009. The observed difference between 2010, 2011 and 2012 was marginally not significant with a relatively lower average in 2012 (Figure 5). There is no statistically significant difference in the altitude of autumn migration in preconstruction and operational period when all species are considered together.

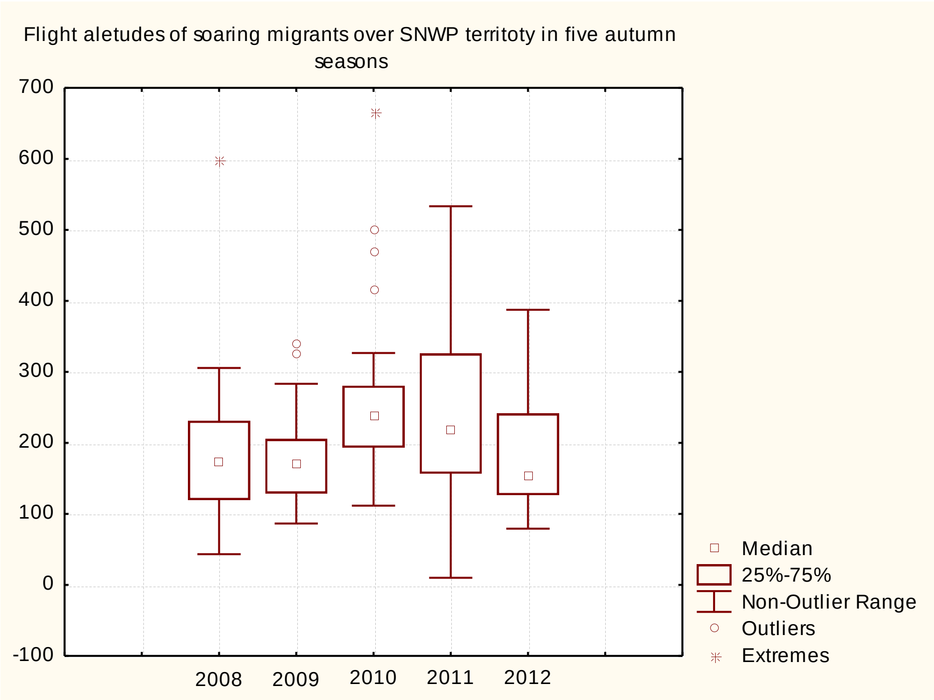


Figure 5. Median altitude of autumn bird migration in 2008, 2009, 2010, 2011 and 2012, with measures of variance. The species included in the calculations are presented in Table 4.

Comparison of the mean altitude of soaring birds passing through the territory in autumn 2008 when the SNWF was not yet constructed with every autumn season of post construction period provide is presented below (Figure 6). The altitude of autumn migration was lower in 2008 compared to 2010 and 2011, but was the same as in 2009 and 2012.

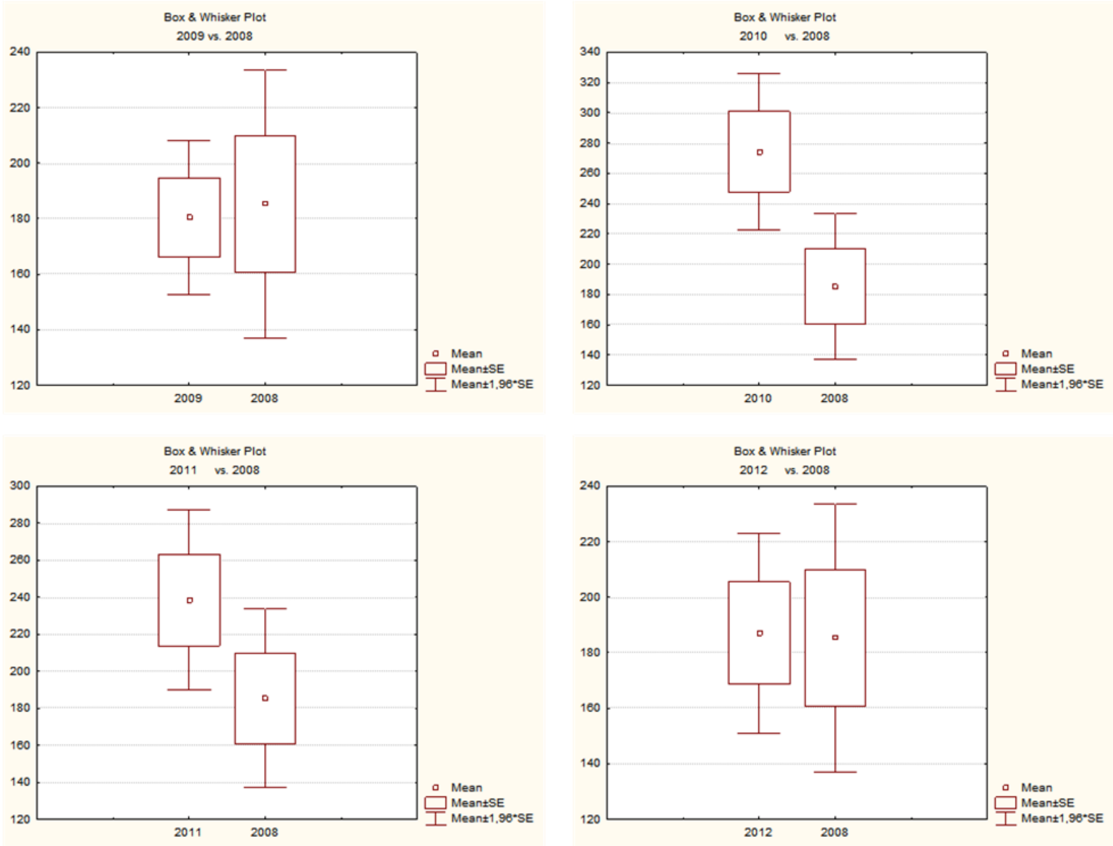


Figure 6. Comparison of the mean altitude of soaring migrants passing through the study area in autumn 2008 when SNWF was not yet constructed, with every autumn season of the post construction period.

The bee-eaters and swallows, as mentioned before in the present report, were analyzed despite the fact of unreliable information collected by visual observation as a method limited by distance-to-observer. Nevertheless, the average altitude of bee-eaters and swallows was in line with the results concerning altitude of migration of soaring bird species (Table 5).

Table 5. Average altitude of flight during autumn migration of bee-eaters and swallows in the period 2008 – 20012 observed in SNWF territory.

Species	2008	2009	2010	2011	2012
H. rustica	28	51	66	19	37
M. apiaster	73	68	128	71	83
Average per year	56	61	121	65	71

These analyses suggest that changes in the flight altitude of soaring migrants have had no consistent character across years but seem unlikely to be related to the operation of

SNWF. Climatic factors are likely to be involved. Regardless, any energetic consequences for migrants avoiding the turbines by way of a change in flight altitude will be immaterial to overall migratory energy budgets (Masden et al. 2009, 2010); if they occur. To date there is no obvious evidence that they do occur.

Direction of autumn bird migration

Taking the same 24 species of soaring birds that were relatively constantly-recorded across years (observed in at least three of the autumn seasons: Table 4) an analysis of flight direction across years involved 4454 observations. In this analysis each flock was considered as a single observation (datum) even if it consisted of, for example, 1000 or more individuals. The number of data (measurements of direction) for 2008, 2009, 2010, 2011, and 2012 were, respectively, 427, 1195, 1343, 696, and 793.

The mean recorded direction of the 24 species is presented in Table 6. Superficially, it was apparent that for all species the directional distribution of recorded flocks varied to only a small degree across years with exception of 2009 when the observation points were moved northward in order to test an early warning system for approaching flocks of birds. Prevailing directions of autumn migration seem to reflect the guiding role of the coast and do not indicate changes in migratory direction through a response to SNWF in years when there was greater consistency in the location of observation points.

Table 6. Mean observed flight direction of autumn migration by species in different years. Directions are given in degrees starting from 0 (North). The species included in the analysis are given in Table 5.

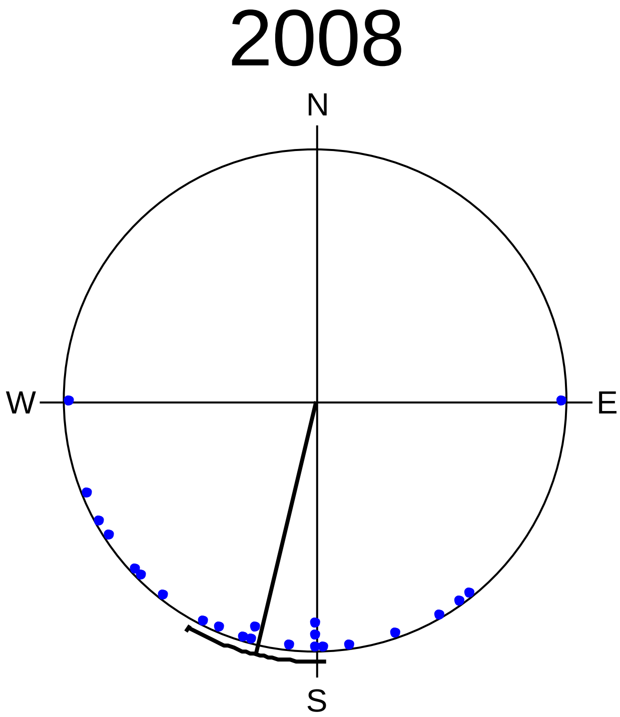
Average flight direction	Year					
Species	2008	2009	2010	2011	2012	Total
A. brevipes	172	151	185	175	179	175
A. cinerea	248	178	146	138	203	173
A. gentilis	195	162	171	180	149	163
A. nisus	218	155	186	193	174	184
A. pennata	180	150	182	165	216	187
A. pomarina	225	173	204	183	193	196
B. buteo	195	150	177	179	179	170

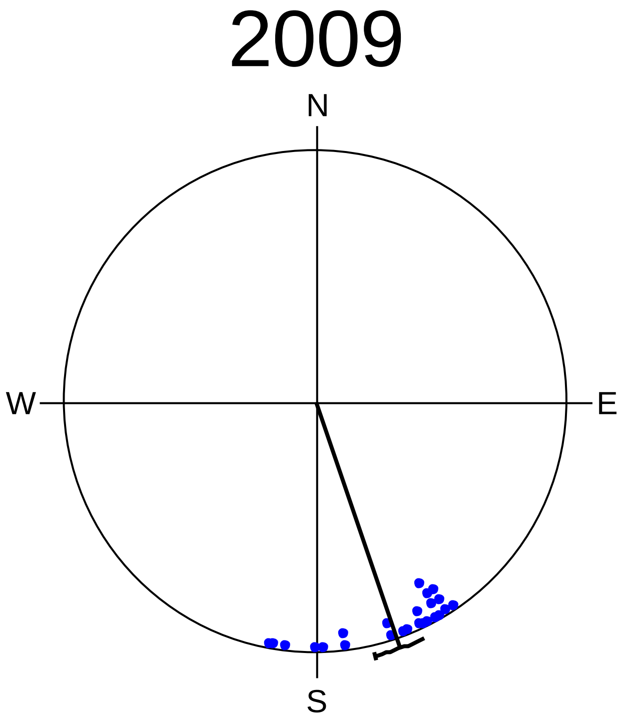
Average flight direction	Year				
B. rufinus	150	158	227	186	188	171
C. aeruginosus	197	150	191	188	175	178
C. ciconia	207	154	209	210	209	201
C. cyaneus	90	180		225		165
C. gallicus	203	150	144	151	129	148
C. macrourus	141	154	180	231	109	162
C. nigra	270	191	225	180	231	225
C. pygargus	237	148	182	183	174	182
F. subbuteo	186	148	174	196	196	177
F. tinnunculus	144	148	177	161	191	156
F. vespertinus	180	159	177	204	218	182
M. migrans	241	153	211	207	189	204
P. apivorus	227	187	201	200	208	203
P. haliaetus	161	190	168	198	169	178
P. leucorodia	180	173	195	180		178
P. onocrotalus		146	195	257	232	207
Ph. carbo	178	162	192	160	121	171
All 24 species	191	154	189	186	182	178

Table 7. Basic statistical parameters of empirical flight directions obtained from visual observations during five autumn seasons in SNWF territory for the 24 ‘core’ soaring bird species.

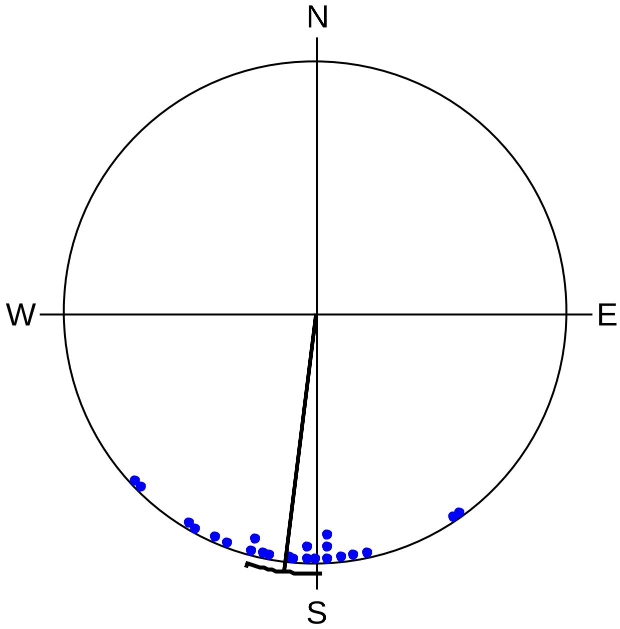
Variable	2008	2009	2010	2011	2012
Number of species	23	24	23	24	22
Mean Vector (μ)	193,49°	161,115°	186,935°	188,292°	184,535°
Length of Mean Vector (r)	0,79	0,969	0,939	0,906	0,853
Concentration	2,743	16,601	8,497	5,581	3,716
Circular Variance	0,21	0,031	0,061	0,094	0,147
Circular Standard Deviation	39,369°	14,285°	20,295°	25,526°	32,3°

The circular (compass) distributions of flight directions of soaring birds are presented in graphs below for each year (Figure 7).

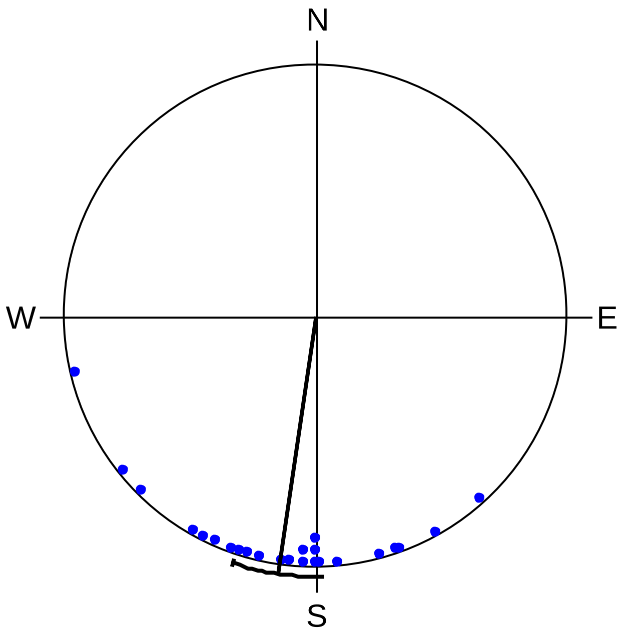

2008
N
W
E
S


2009
N
W
E
S

2010



2011



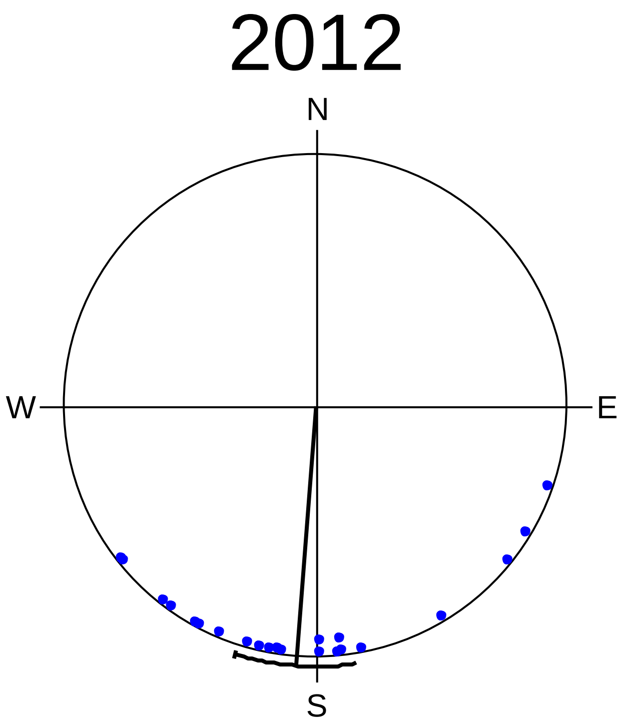


Figure 7. Graphical representations of the average flight directions of the 24 ‘core’ soaring bird species by year: each record = 1 species (see Table 4).

Not surprisingly these graphs (Figure 7) confirm the descriptive statistics presented in Table 6. They illustrate the exceptional nature of the 2009 records (as noted previously, likely due to the radical change in the observation points in this year) and no evidence for a major deviation of the migratory direction of the principle soaring bird species as a consequence of SNWF.

Acknowledging the caveats that should be applied to the observations of hirundines (swifts, martins, swallows) and bee-eaters, as described above, analysis of the data for these birds may nevertheless serve to illuminate further this issue. In order to reduce the level of subjective error in estimation of flight direction for species such as swallows and bee-eaters, that generally flying in dispersed flocks, the data were grouped in 16 (22.5 degree) sectors. Average results for the barn swallow and the bee-eater are tabulated in Table 8.

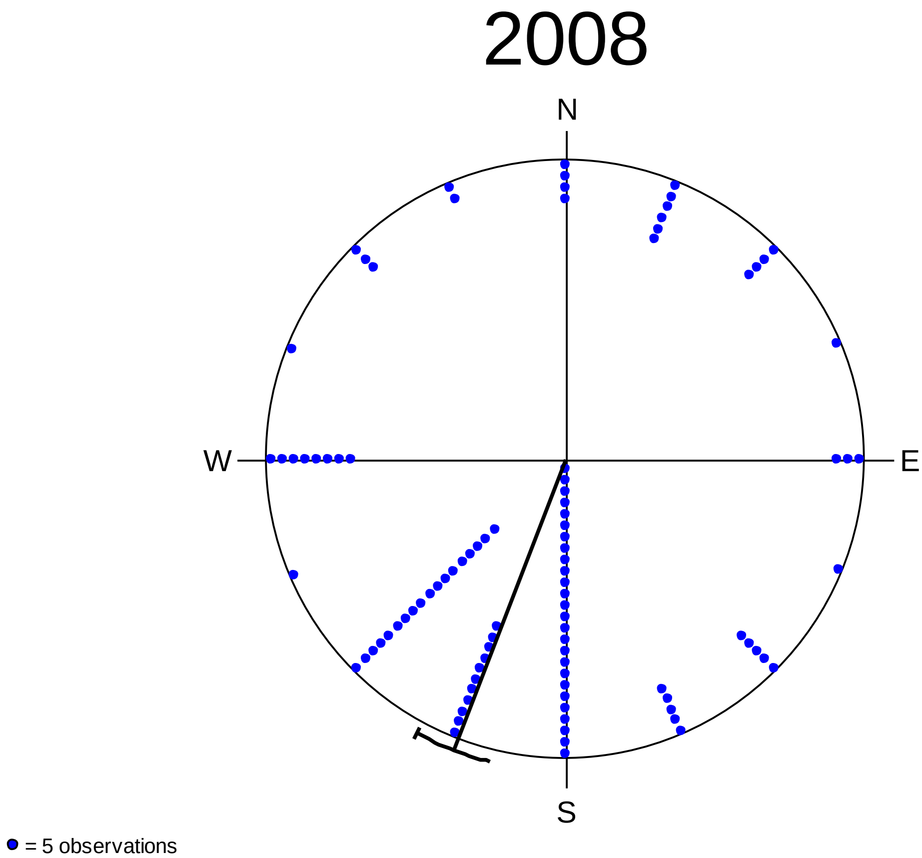
Table 8. Average flight directions of barn swallows *H. rustica* and bee-eaters *M. apiaster* as observed in SNWF territory across five autumn seasons.

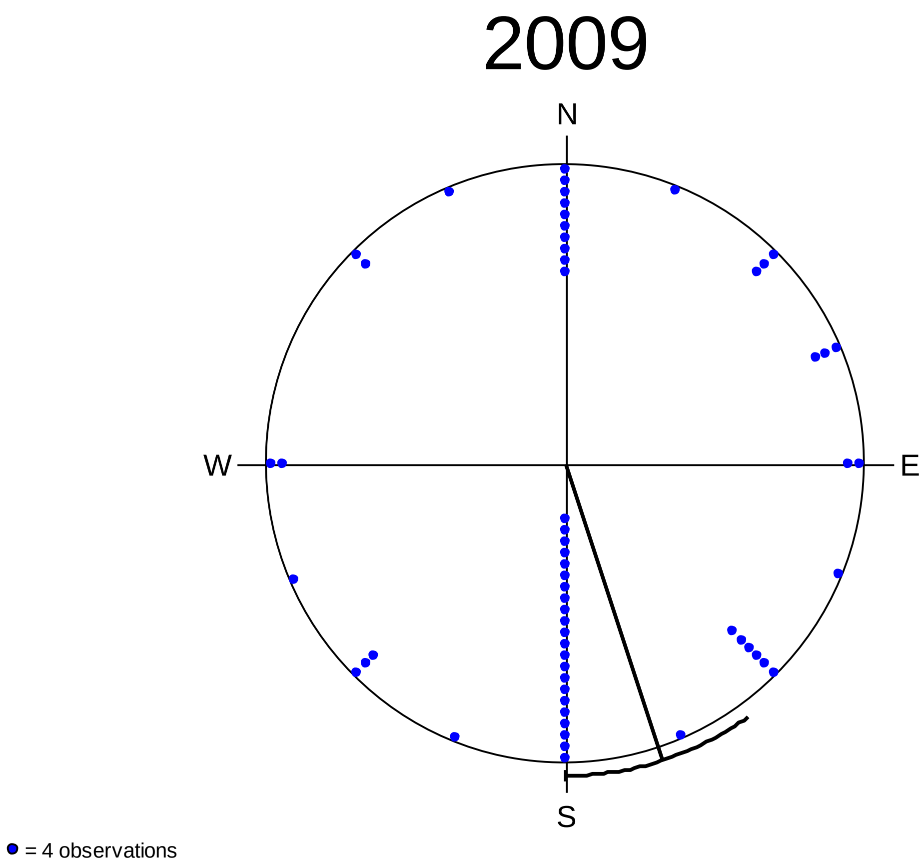
Species	2008	2009	2010	2011	2012	Total
H. rustica	158	144	204	169	172	157
M. apiaster	191	142	192	186	187	176
Grand Total	179	143	193	184	183	171

Further analysis of bee-eater *M. apiaster* flight directions is presented below through descriptive statistics (Table 9) and graphically (Figure 8).

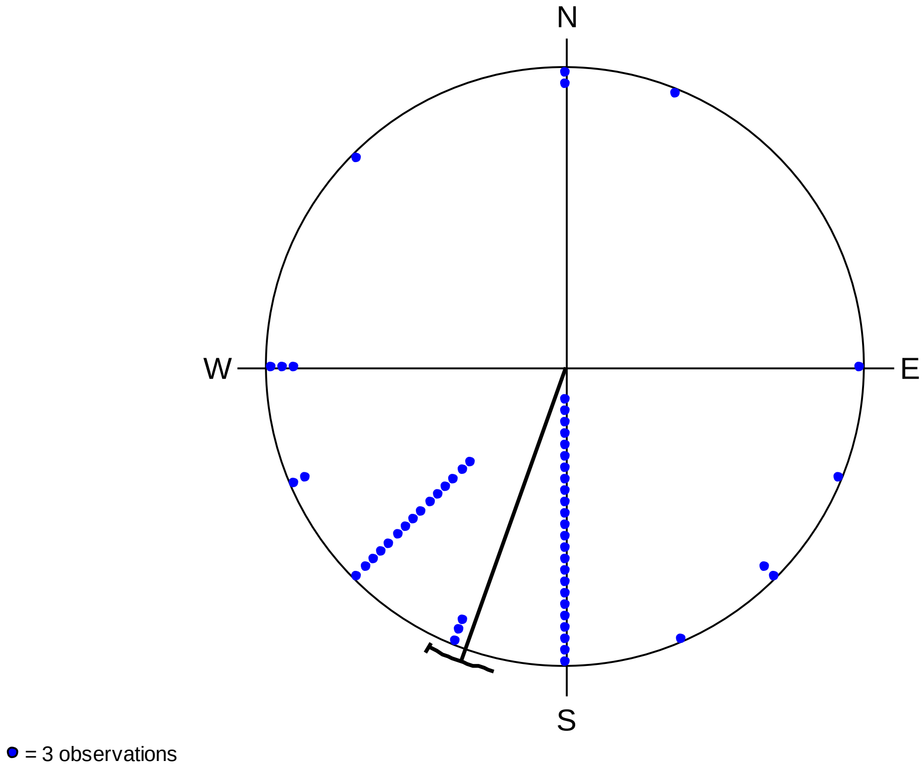
Table 9. Basic statistical parameters of empirical flight directions obtained from visual observations during five autumn seasons in SNWF territory for the bee-eater *M. apiaster*.

Variable	2008	2009	2010	2011	2112
Data Type	Angles	Angles	Angles	Angles	Angles
Number of Observations	461	213	159	100	108
Data Grouped?	Yes	Yes	Yes	Yes	Yes
Group Width (& Number of Groups)	22,5° (16)	22,5° (16)	22,5° (16)	22,5° (16)	22,5° (16)
Mean Vector (μ)	201,237°	162,006°	199,725°	192,084°	199,845°
Length of Mean Vector (r)	0,476	0,298	0,768	0,709	0,632
Concentration	1,081	0,624	2,516	2,062	1,649
Circular Variance	0,524	0,702	0,232	0,291	0,368
Circular Standard Deviation	69,802°	89,164°	41,682°	47,543°	54,855°

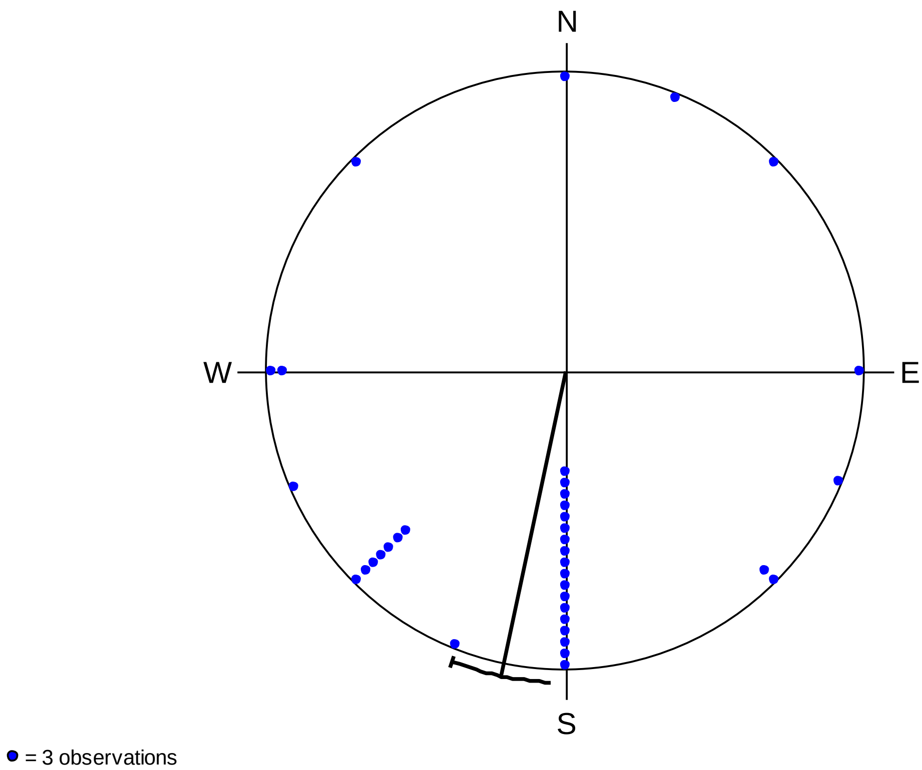

2008
N
W
E
S
= 5 observations


2009
N
W
E
S
= 4 observations

2010



2011



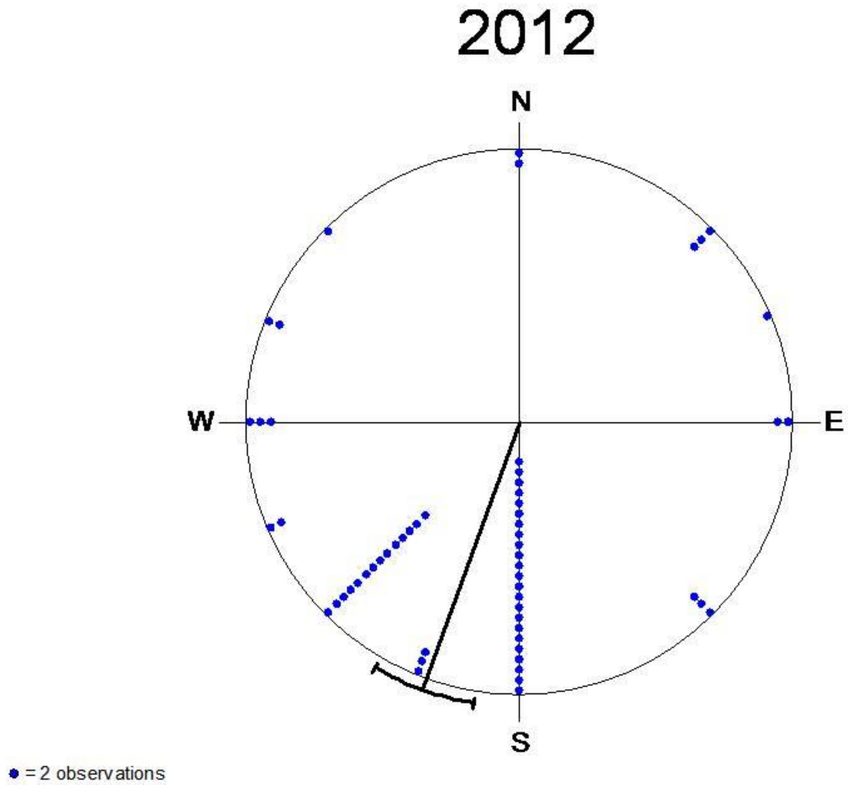


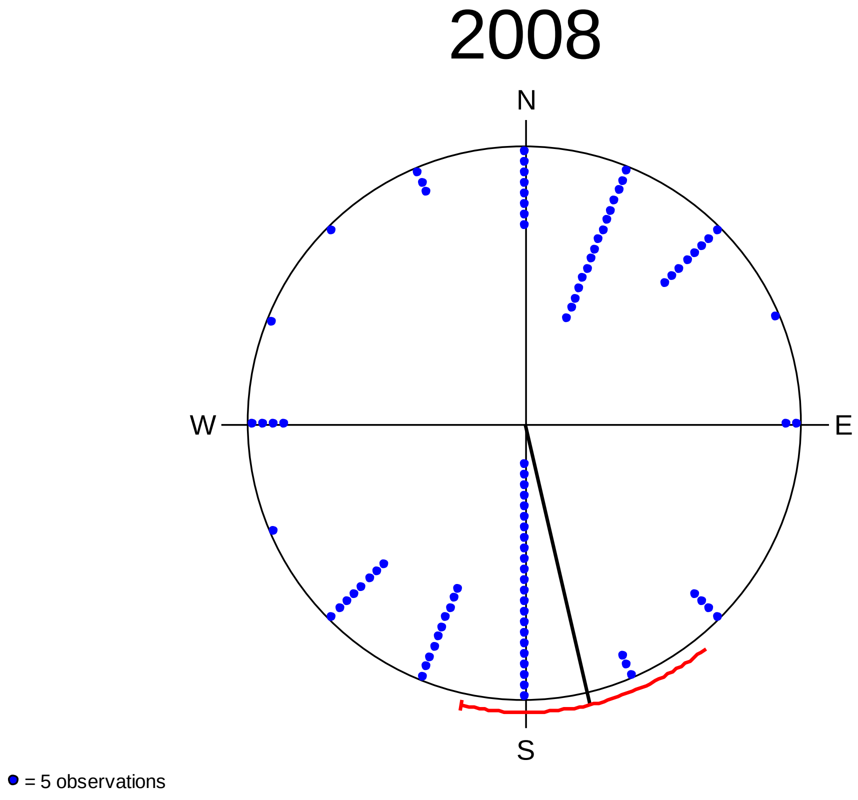
Figure 8. Graphical representations of the flight directions of bee-eaters by year.

Further analysis of barn swallows *H. rustica* flight directions is presented below through descriptive statistics (Table 10) and graphically (Figure 9).

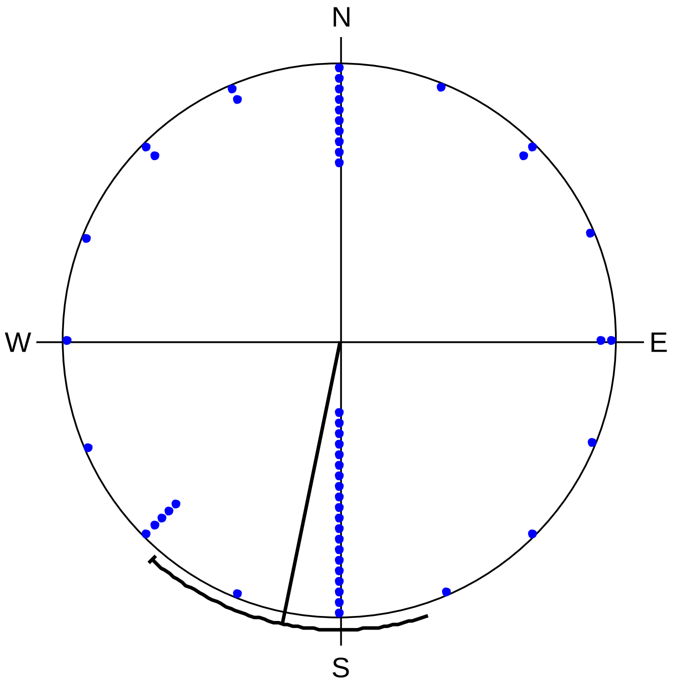
Table 10. Basic statistical parameters of empirically obtained flight directions of barn swallows (*H. rustica*) after standard visual observations in five autumn seasons in SNWP territory (for details see the methods section).

Variable	2008	2009	2010	2011	2012
Data Type	Angles	Angles	Angles	Angles	Angles
Number of Observations	433	132	19	8	48
Group Width (& Number of Groups)	22,5° (16)	22,5° (16)	45° (8)	45° (8)	22,5° (16)
Mean Vector (μ)	167,036°	191,631°	207,178°	173,083°	174,061°
Length of Mean Vector (r)	0,147	0,233	0,822	0,624	0,37

Variable	2008	2009	2010	2011	2012
Concentration	0,297	0,479	3,155	1,455	0,797
Circular Variance	0,853	0,767	0,178	0,376	0,63
Circular Standard Deviation	112,186°	97,802°	35,9°	55,655°	80,764°

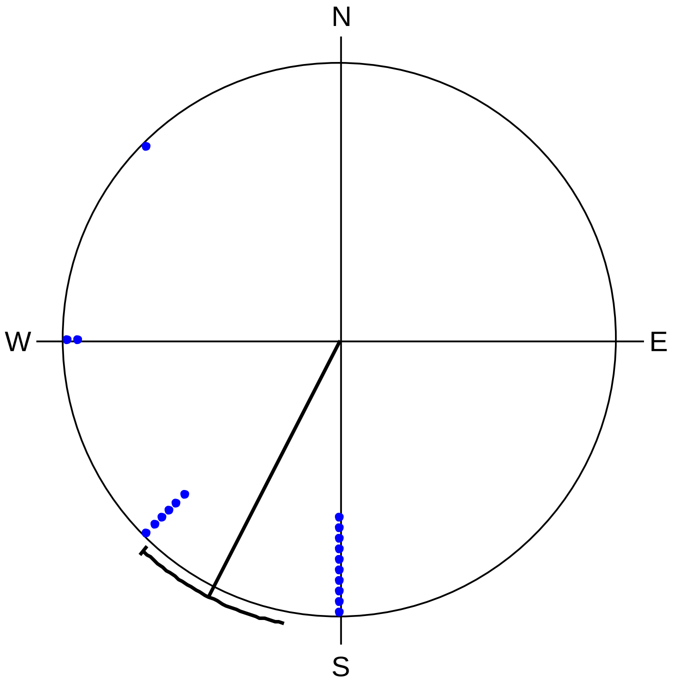


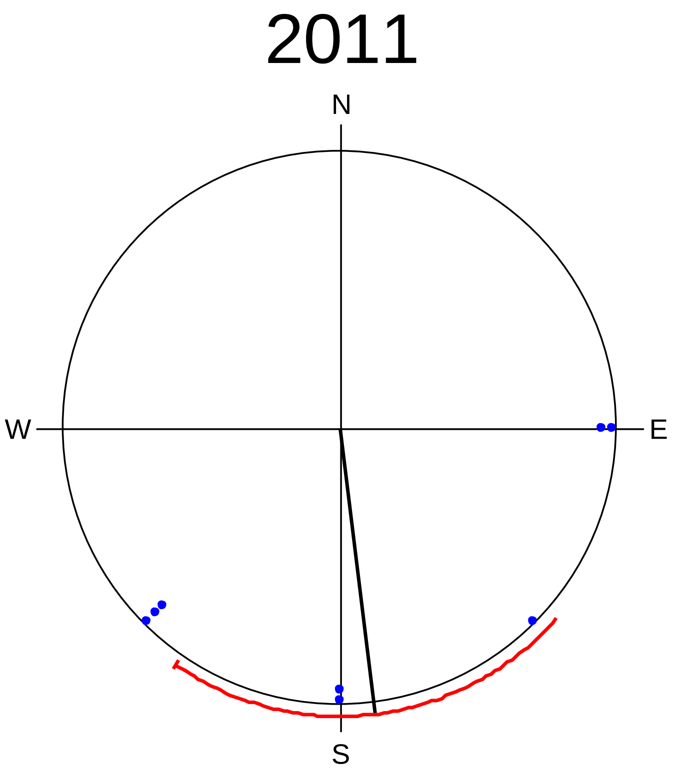
2009



= 3 observations

2010





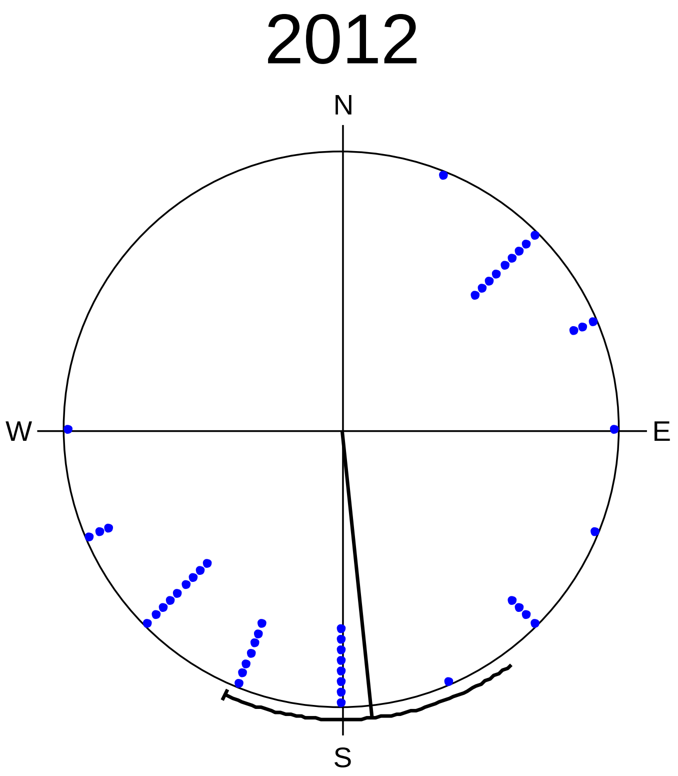


Figure 8. Graphical representations of the flight directions of barn swallows by year.

Circular statistics of observed directional distributions of bee-eaters and swallows largely corresponded to those obtained from soaring birds in the same periods. Barn swallow flight directions were relatively less concentrated which reflected the feeding behaviour of the species during migration, when feeding activity around observation points lead to registrations in multiple directions that did not always correspond with the broad seasonal migration direction in autumn.

Table 11. Results of statistical analyses (Watson-Williams F-tests) comparing the directional distributions (vectors) for all bird flocks/individuals recorded across five autumn seasons. Significant differences are highlighted in grey.

F scores (lower half) and probabilities (upper half)					
	2008	2009	2010	2011	2012
2008	-----	0,004	0,292	0,907	0,645
2009	9,853	-----	1,07E-04	0,004	3,92E-04
2010	1,15	19,888	-----	0,218	0,48
2011	0,014	10,044	1,582	-----	0,536
2012	0,217	15,92	0,511	0,391	-----

Statistical comparisons of the directional distributions between the five autumn seasons are presented in Table 11. It is apparent from these comparisons that 2009 was an 'exceptional' year: mean direction of the autumn migration in 2009 was not only significantly different to that in 2008 (preconstruction), but also when compared to the direction in 2010, 2011 and 2012 (active operational) periods. These differences are most likely related to location of observation points in autumn 2009, which were moved northward in order to observe the behaviour of the approaching birds in relation to testing the early warning system for the first time in this season.

The pooled direction of autumn migration for all species across the five years of study does not deviate markedly from a southerly seasonal autumn migration direction (as expected in the absence of the wind farm, and the location of study area), even though a deviational effect of the wind farm (in some form) should have been obvious, given the wind farm's presence in four of the five years of study (Figure 9).

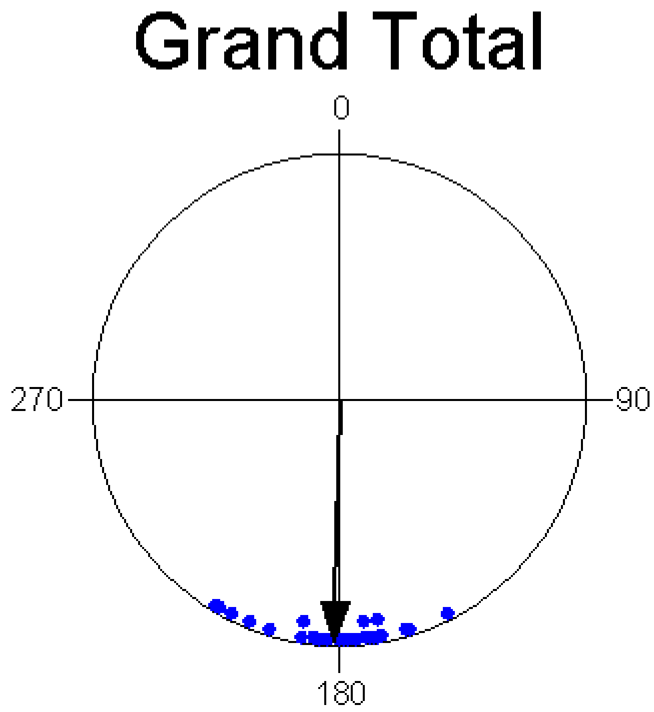


Figure 9. Pooled data on direction of autumn migration of all species across the five years of the study in SNWF territory.

Overall, therefore, there is no evidence under the scale and form of analysis for a major directional change in the flight orientation behaviour of autumn migrants (macro-avoidance) as a result of the wind farm. At the scales considered, birds that were observed to enter the vicinity of the wind farm did not demonstrate any macro-avoidance of the turbines which could thereby be considered as a change of migratory direction and, consequently, contribute to a major change in migratory route or any detrimental effect on energy budgets.

The radar data

Location of the fixed beam Bird Scan radar in autumn 2012 was the same as in autumn 2010, as noted earlier. The program for the day time operation of the radar during the autumn 2012 study period provided information for flocks and single birds in the altitudinal zone between 25 and 250 metres as in previous autumn seasons since

2009. All registered flocks were identified and used to calibrate the analysis of visual observations presented above.

The data gathered during nocturnal measurements of bird migration have been archived and will be analysed in order to compare dynamics and altitudinal distributions. These results will be the subject of a special report concerning nocturnal migration in spring and autumn for the period of radar operation in the wind park territory, 2009 - 2012.

Spatial and temporal distribution of observed 'major' influxes of soaring migrants

The number of flocks of migratory birds in autumn 2012 was probably relatively low because of the low number of large influxes of soaring birds, such as white storks and pelicans, across SNWF territory. Prevailing NE wind directions in autumn 2012 were probably the main reason for relatively low numbers of flocks of such soaring birds. The only substantial numbers of migrants in flocks were observed on the days with westerly winds: 18th and 28th August and 21st – 23rd September.

Notable records in this respect were as follows:

- White stork: a flock of 1400 birds crossed SNWF from the NNE on 18th August;
- Honey Buzzard: a group of 11 birds crossed from N on 28th August, and 18 birds skirted the southern limits of the wind farm, coming from the NE, on the same day;
- White pelican: 630 birds were seen to cross SNWF from the N on 21st September;
- Red-footed falcon: 84 falcons were seen crossing on 23rd September from the N, and the day before 170 birds were recorded coming from the NE.

These records confirmed previous analyses of data from other years, presented in earlier reports (http://www.aesgeoenergy.com/site/Studies.html) indicating that SNWF is to the east of the main migratory flyway of the *Via Pontica* and so only hosts major numbers of migrants when unusual westerly wind conditions shift birds from the flyway.

Turbine Shutdown System

All of these flocks in 2012, likely shifted by a change in weather, were anticipated climatically and then physically traced by the system of observation points and the radar system: their presence transmitted to the Turbine Shutdown System (TSS). The TSS was applied in these instances, and also in cases when it was known that single birds of conservation importance were present in the vicinity of SNWF. Hence, the TSS was applied to groups of turbines for several hours throughout the period of the monitoring 15th August – 30th September, but particularly in the periods 18th and 28th August and 21st – 23rd September when a change in wind conditions brought greater numbers of soaring migrants into the wind park territory.

Collision victim monitoring

The numbers of turbines searched during every autumn of operational period of the wind park are presented in Table 12.

Table 12. Number of carcass searches per autumn and turbine in the operational period of SNWF.

Turbine number	**Autumn 2010**	**Autumn 2011**	**Autumn 2012**	**Total searches**
8	6	8	8	22
9	6	8	7	21
10	6	7	10	23
11	6	7	9	22
12	6	10	9	25
13	6	9	9	24
14	6	9	7	22
15	6	9	7	22

Turbine number	Autumn 2010	Autumn 2011	Autumn 2012	Total searches
16	6	6	9	21
17	6	6	9	21
18	6	4	8	18
19	6	8	9	23
20	6	9	10	25
21	1	6	8	15
22	6	6	8	20
23	6	6	8	20
24	6	7	7	20
25	6	2	8	16
26	6	8	8	22
27	6	2	8	16
28	6	2	5	13
29	6	8	7	21
31	1	9	7	17
32	6	9	8	23
33	6	8	7	21
34	6	8	7	21
35	7	8	7	22
36	6	9	7	22
37	6	9	9	24
38	6	9	6	21
39	6	8	7	21
40	6	7	8	21
41	6	7	6	19
42	7	7	7	21
43	11	9	7	27
44	11	7	7	25
45	6	8	8	22
46	6	9	8	23

Turbine number	**Autumn 2010**	**Autumn 2011**	**Autumn 2012**	**Total searches**
47	6	9	7	22
48	6	9	7	22
49	6	10	7	23
50	6	10	7	23
51	6	9	7	22
52	6	9	5	20
53	6	9	6	21
54	6	8	7	21
55	6	9	7	22
56	6	8	7	21
57	6	9	7	22
58	6	9	7	22
59	7	9	7	23
60	6	9	7	22
Grand Total	**315**	**404**	**389**	**1108**

Under this search regime during the autumn migration period, six remains of identifiable birds have been found that can be attributable to collision strike with turbine blades 2010 - 2012. Numbers of birds found dead under turbines and species' conservation status according to IUCN are presented in Table 13.

Table 13. The number of carcasses found in periods of autumn migration during three years of operation of SNWF. For details see Methods and reports on the autumn migration period in previous years.

Species	**Intact bodies found**	**Conservation status according to IUCN**
Acrocephalus palustris	1	Least Concern (IUCN 3.1
Delichon urbicum	2	Least Concern (IUCN 3.1
Gyps fulvus	1	Least Concern (IUCN 3.1
Lanius collurio	1	Least Concern (IUCN 3.1
Sylvia atricapilla	1	Least Concern (IUCN 3.1
Grand Total	**6**	Least Concern (IUCN 3.1

CONCLUSIONS

1. The numbers of species varied across years with no trend for a decrease after SNWF was constructed and started its operation.
2. The absolute number of observed birds naturally varied by years but with no trend for a decrease after SNWF was constructed and started its operation.
3. The altitude of flight also varied by years but with no overall trend for an increase after SNWF was constructed and started its operation.
4. There is no evidence for change in migratory direction (avoidance) associated with the wind park territory. Records from 2009 were exceptional and this was probably because of a major shift in observation point location in this year. At a gross scale, birds did not demonstrate macro-avoidance of the turbines that could be considered as a change of migratory direction and, thereby, a change of migratory route.
5. The occurrence of autumn migrants in all autumn seasons was strongly correlated with typically short periods of a few days when strong westerly winds occurred.
6. The number of collision victims recorded during the operational period of the wind park in periods of autumn migration was extremely low, considering the

number of birds passing through the wind farm. Records of collision mortality do not indicate any possibility of an adverse impact of SNWF on any bird population.

7. The application of TSS may have had a significant mitigation effect on the potential collisison risk and direct mortality registered in the operational period of SNWF.
8. The substantial data collected to date indicate that the operation of SNWF does not constitute a major obstacle or threat, either physically or demographically, to populations of migrants passing through its environs.

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