Bird migration monitoring in the Saint Nikola Wind Farm, Kaliakra region, in autumn 2017, and an analysis of potential impact after eight years of operation

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Contents

SUMMARY

1. This report presents the results of 78 consecutive days of monitoring and mitigation at Saint Nikola Wind Farm (SNWF) in 2017, its 8th operational year. The continued purpose is to investigate the possible impacts of SNWF on migrating birds.

2. Spatial and temporal dynamics in the numbers of different species passing through the wind farm territory during autumn migration 2017 (15 August to 31 October) are presented. The data from the autumn monitoring in the years 2008 to 2017 are used to investigate the potential change in species composition, numbers, altitude or the flight direction of birds observed in these nine years at SNWF.

3. The variations in numbers of species, absolute number of birds, overall altitudes of flight and migratory direction of birds most sensitive to wind turbines do not indicate an adverse effect of the wind farm on diurnal migrating birds.

4. The Turbine Shutdown System (TSS) 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 single birds and flocks of endangered bird species.

5. Regular searches under operational turbines for collision victims were continued, as in several previous years. In autumn 2017 these searches recorded only casualties, for several species of no conservation concern: four Common Swifts, three Yellow-legged gulls, one Chiffchaff, one Willow warbler, one Common moorhen, one Grey partridge, one Red-backed shrike, one Red-breasted flycatcher and one Scops owl.

6. The predicted mortality rates by species based on preconstruction data on numbers of migrating birds are not supported by the mortality observed during any of the eight years of operation of SNWF. The levels of mortality predicted pre-construction have not been recorded during any year of operation. This is largely because 'worst case' predictions were based on BSPB (Bulgarian BirdLife partner) data that substantially exaggerated the numbers of migrants passing through SNWF.

7. The results to date continue to indicate that SNWF does not constitute a significant displacement/disturbing obstacle or mortality threat, either physically or demographically, to any of the populations of diurnal autumn migrants observed in this study.

INTRODUCTION

AES Geo Energy OOD constructed a 156 MW wind farm consisting of 52 turbines: 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 stationary), and in the autumns of 2010 - 2017 SNWF was operational.

In previous SNWF autumn reports the major focus was assessment of potential barrier effect on birds migrating through the territory and the level of collision mortality of migrants. The analysis of the data until now showed no evidence for cumulative long term changes in the migratory bird fauna. 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 negligible collision mortality of migrating birds was found; indicating a high micro avoidance rate of the turbines by migrating bird species.

The present report updates the information on spatial distribution and temporal presence of birds in SNWF during autumn 2017 with, as in previous reports, special focus on soaring species deemed most sensitive to wind turbines. The observed increase of birds in SNWF in previous autumn seasons under westerly winds was tested statistically in a detailed correlative analysis of wind direction and bird numbers in autumn 2017.

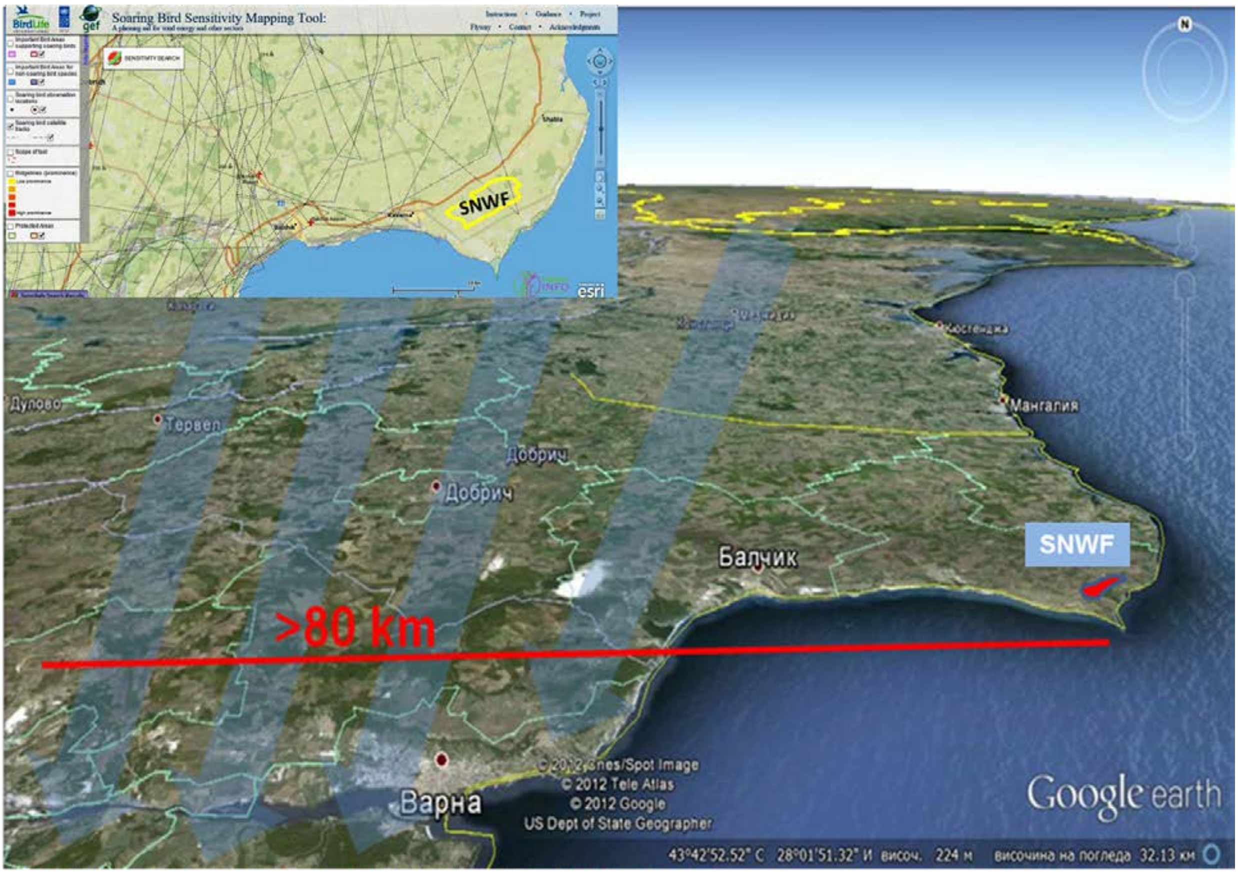

Figure 1. Schematic representation of the main autumnal migratory flyway (blue arrows) and the location of SNWF (in red) based on visual observations and satellite tracks for this region (upper left corner: https://maps.birdlife.org/MSBtool/)

METHODS

The study area

SNWF is located in NE Bulgaria, approximately three to seven kilometers inland of the Black Sea coast and the cape of Kaliakra (Fig. 1). 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. The location of observation points is presented in Fig.2.

Study duration and equipment

The study was carried out between 15 August and 31 October 2017 using standard methods that are comparable for all ten autumn seasons since studies began in 2008, using up to six field ornithologists making visual observations. The surveys were made as in previous seasons during the day, in a standard interval of time between 8 AM and 6 PM astronomic time (for details see http://www.aesgeoenergy.com/site/Studies.html)

Basic Visual Observation Protocol

The autumn 2017 study involved direct visual survey of all passing birds from several observation points (Fig. 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 previously 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. Map of the "SNWF" study area (red plot), and the "core study area" (brown area) covered by the autumn monitoring 2017 observations and location of the observation points (white circles).

As noted in previous reports, 2009 was exceptional in the spatial survey protocol because the observation points were moved northward to test the early warning system (TSS) for approaching flocks of birds. The northerly shift in the observation points in 2009 means that many data of migratory metrics (notably, flight direction) were likely not comparable with the years before or since. In 2009, SNWF had been constructed but was not operational. The basic temporal survey protocol was otherwise not changed in the period 2008 – 2017 (other than the temporal extension in 2013 to 2017 to cover October, additionally) in order to allow comparable data collection between years.

As described in several previous reports, it was apparent in earlier years that the occurrence of relatively unusual westerly winds was the main reason for influxes of soaring birds in SNWF territory. Hence this feature has been subjected to detailed analysis in this autumn 2017 report.

All details about the specific visual observation protocol are presented in a number of previous autumn reports and in the Owner Monitoring Plan (OMP) and will not be repeated here: http://www.aesgeoenergy.com/site/images/21.pdf (studies page).

All observers were qualified specialists in carrying out the surveys of bird migration for many years including previous autumn surveys at SNWF.

List of participants in the autumn observations, 2017

Dr Pavel Zehtindjiev - Senior Field Ornithologist
Institute of Biodiversity and Ecosystem Research Bulgarian Academy of Sciences

Dr Victor Metodiev Vasilev - Field ornithologist
Senior researcher in the Faculty of Biology, University of Shumen, Bulgaria
BSPB (Bird Life Bulgaria) member

Ivailo Antonov Raykov - Field ornithologist
Museum of Natural History, Varna
BSPB (Bird Life Bulgaria) member

Strahil Georgiev Peev - Field ornithologist
Qualified carcass searcher
PhD Student, Institute of Biodiversity and Ecosystem Research
BSPB (Bird Life Bulgaria) member

Kiril Ivanov Bedev - Field ornithologist
Qualified carcass searcher
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Yanko Sabev Yankov - Field ornithologist
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As already stated, over the years 2008-2012 the autumn monitoring lasted for the period of most intensive migration - August and September. Since 2013 (including 2017), we have extended the period of observation until the end of October. In order to provide comparability between the four most recent seasons and previous years, however, to avoid bias associated with the extended observation period in 2013 to 2017, the data presented below are based on a comparable time period (15 August to 30 September) unless otherwise stated.

Method of 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 par. 1.6 and 2.4 of the Owners Monitoring Plan (OMP http://www.aesgeoenergy.com/site/Studies.html.). Staged autumn trials were conducted in two previous years examining carcass removal/disappearance rates and searcher efficiency rates. These results, presented in previous autumn reports, should be borne in mind as adjustment factors when considering the results for carcasses and numbers found during the systematic searches under turbines during 2017.

Statistical methods

The number of observed species, individuals as well as their average altitude of flight (by species and years) is presented in a number of tables for direct comparison across the autumn seasons of 2008 - 2017.

The altitude of migration in different autumn 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. http://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 with Oriana (Oriana - Copyright © 1994-2009 Kovach Computing Services). This program compares two or more sets of circular distributions (directions) to determine if they differ. The tests were performed pairwise, so that each pair of samples was compared separately.

Many of the basic statistical parameters of circular distributions (directions) 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 has two properties; its direction (the mean angle, **μ**) and its length (often referred to as **r**). The length ranges from 0 to 1; a higher r value indicates that the observations are clustered more closely around the mean than a lower one. Details about the Oriana software are available at: http://www.kovcomp.com/

Wind direction was recorded by a permanent meteorological station set up at SNWF. A correlation between predominant prevailing daily wind direction and number of birds recorded daily was performed using the software Oriana (Oriana - Copyright © 1994-2009 Kovach Computing Services) for correlation of circular and linear data. The circular-linear correlation coefficient (Fisher, 1993, p.145; Mardia & Jupp, 2000, p.245; Zar, 1999, p. 651) calculates the correlation between a circular variable and a linear one. This correlation coefficient ranges from 0 to 1.

Turbine Shutdown System (TSS)

The principles to selectively stop specific turbines or the entire wind park to reduce risk of collisions are described in par. 1.5 of the Owners Monitoring Plan (OMP).

The TSS protocol was followed in order to reduce collision risk during the extended period of study in autumn 2017, between 15 August and 31 October. Turbine shutdowns are ordered by the Senior Field Ornithologist or -when delegated - to field ornithologists in the case of any perceived collision risk to an influx of potentially collision-sensitive species.

RESULTS AND DISCUSSION

Composition of species and number of birds passing through SNWF

The occurrence of species across all years is presented in Table 1. A total of 132 bird species have been observed in the wind farm territory during the consecutive autumn seasons of 2008 to 2017. The number of observed species varied from 48 to 82 in different years. 26 species were observed every autumn season in the period 2008 – 2017. Regular migrants through the territory included White Pelican, White Stork, Levant Sparrowhawk, Common Buzzard, Honey Buzzard and the Lesser Spotted Eagle. No species recorded in 2008, pre-construction, have not been recorded in at least one of the nine subsequent years, post-construction. By contrast, another 55 species of birds were not recorded in 2008, but were observed at least in one of eight post-construction autumn seasons. Among such species were, for example, many birds of prey like Golden Eagle, Saker Falcon, Black Kite; waders like Northern Lapwing, Green Sandpiper, Common Greenshank, Eurasian Stone Curlew; herons like Purple Heron, Great Egret, Little Egret; and many small passerine bird species. The occurrence of these relatively rare species after construction should be attributed to vagrancy and to the chances they could be recorded due to the substantially longer survey post-construction period (nine years) compared to pre-construction (one year).

Four new species are observed for the first time in SNWF territory in autumn 2017. First one is the Little Gull (*Larus minutus*). The species can be found breeding in northern Scandinavia, the Baltic republics and western Russia to western Siberia, in eastern Siberia, and in the Great Lakes of North America. Its distribution expands in winter to include most of the Mediterranean, Black Sea and Caspian Sea coastlines, as well as the Atlantic coast of Europe and the north-west coast of the U.S.A. The population size is very large, and hence does not approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10 % in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern (http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22694469A89503500.en). The second new species is Ruddy Shelduck (*Tadorna ferruginea*) which is a Red Data book species in Bulgaria (critically endangered). It is common breeder in the open areas of NE Bulgaria including the region of the country adjacent to SNWF territory. The species is observed in SNWF in winter seasons before. The observation of eight birds is most probably a family in a period of post breeding movements when this species forms aggregations: well known in big lakes of Turkey and Armenia (http://e-ecodb.bas.bg/rdb/bg/vol2/Taferrug.html). The third new species is Short-eared Owl (*Asio flammeus*). The Short-eared Owl occurs on all continents except Antarctica and Australia, thus it has one of the most widespread distributions of any bird. *A. flammeus* breeds in Europe, Asia, North and South America, the Caribbean, Hawaii and the Galápagos Islands. This is a Least Concern species according IUCN criteria. Its activity in the day time is unusual and probably this is the reason why it was not observed previous seasons in SNWF territory. The fourth new species for the territory of SNWF is the Merlin (*Falco columbarius*). The population size of Merlin is extremely large and widely distributed, and hence does not approach the thresholds for Vulnerable under the population size criterion. In Bulgaria the species is relatively rare during migration and in winter.

There is no apparent substantive difference in composition of species migrating through the wind farm observed in 2008 (before the construction of the wind farm) and during the later period when the wind farm was present (2009 – 2017). Variations in the species of common passerine migrants recorded in some of the years between 2008 and 2017 are explained by the scarce habitats for these mostly forest birds in the territory of SNWF. All species recorded in 2008, before SNWF was constructed, has been recorded subsequently in years after construction; and several species have been recorded in the nine years after construction that were not recorded in 2008. While this can illustrate that SNWF has not impaired the occurrence of species on migration, such differences should not be attributed to any 'beneficial' effects of SNWF but to the greater number of years of observation post-construction.

Table 1. List of species observed in SNWF during 15 August to 30 September in pre-construction (2008) and post-construction (2009 to 2017 in grey) periods of SNWF. Hatched cells represent the years when the species was registered in SNWF.

N	Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	*A. albifrons*										
2	*A. apus*										
3	*A. arvensis*										
4	*A. brevipes*										
5	*A. campestris*										
6	*A. cervinus*										
7	*A. chrysaetos*										
8	*A. cinerea*										
9	*A. gentilis*										
10	*A. flammeus*										
11	*A. heliaca*										
12	*A.nipalensis*										
13	*A. melba*										
14	*A. nisus*										
15	*A. pennata*										
16	*A. pomarina*										
17	*A. pratensis*										
18	*A. purpurea*										
19	*A.rapax*										
20	*A. trivialis*										
21	*B. buteo*										
22	*B. oedicnemus*										
23	*B. rufinus*										
24	*B.b. vulpinus*										
25	*B.lagopus*										
26	*C. aeruginosus*										
27	*C. cannabina*										
28	*C. canorus*										
29	*C. carduelis*										
30	*C. chloris*										
31	*C. ciconia*										
32	*C. coccothraustes*										
33	*C. corax*										
34	*C. cornix*										

N	Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
35	*C. coturnix*										
36	*C. cyaneus*										
37	*C. frugilegus*										
38	*C. gallicus*										
39	*C. garrulus*										
40	*C. livia domestica*										
41	*C. macrourus*										
42	*C. monedula*										
43	*C. nigra*										
44	*C. olor*										
45	*C. palumbus*										
46	*C. oenans*										
47	*C. pygargus*										
48	*D. major*										
49	*D.syriacus*										
50	*D. urbica*										
51	*E. alba*										
52	*E. calandra*										
53	*E. garzetta*										
54	*E. hortulana*										
55	*E. melanocephala*										
56	*F. cherrug*										
57	*F. coelebs*										
58	*F. columbarius*										
59	*F. eleonorae*										
60	*F. naumanni*										
61	*F. parva*										
62	*F. peregrinus*										
63	*F. subbuteo*										
64	*F. tinnunculus*										
65	*F. vespertinus*										
66	*G. fulvus*										
67	*G. glandarius*										
68	*G. grus*										
69	*G. cristata*										
70	*H. daurica*										
71	*H. icterina*										
72	*H. pallida*										
73	*H. rustica*										
74	*H. albicilla*										
75	*J. torquila*										
76	*L. cachinnans*										
77	*L. collurio*										
78	*L. megarhynchos*										
79	*L. melanocephalus*										
80	*L. minutus*										
81	*L. minor*										

N	Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
82	*L. ridibundus*										
83	*M. alba*										
84	*M. apiaster*										
85	*M. calandra*										
86	*M. cinerea*										
87	*M. flava*										
88	*M. migrans*										
89	*M. milvus*										
90	*M. striata*										
91	*N. percnopterus*										
92	*O. hispanica*										
93	*O. isabellina*										
94	*O. oenanthe*										
95	*O. oriolus*										
96	*O. pleschanka*										
97	*P. apivorus*										
98	*P. caeruleus*										
99	*P. crispus*										
100	*P. haliaetus*										
101	*P. leucorodia*										
102	*P. major*										
103	*P. montanus*										
104	*P. onocrotalus*										
105	*P. perdix*										
106	*P. pica*										
107	*P. viridis*										
108	*Ph. carbo*										
109	*Ph. collybita*										
110	*Ph. trochilus*										
111	*Pl. falcinellus*										
112	*Ph. pygmaeus*										
113	*Ph. ochrurus*										
114	*Ph. phoenicurus*										
115	*R. riparia*										
116	*S. borin*										
117	*S. communis*										
118	*S. curruca*										
119	*S. rubetra*										
120	*S. vulgaris*										
121	*St. hirundo*										
122	*Str. decaocto*										
123	*Str. turtur*										
124	*T. nebularia*										
125	*T. glareola*										
126	*T. tadorna*										
127	*T. ferruginea*										
128	*T. ochropus*										

N	Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
129	*T. merula*										
130	*T.viscivorus*										
131	*U. epops*										
132	*V. vanellus*										
	Number of species	77	82	48	71	79	81	79	66	60	69

The observed variations in the number of species observed in the study area is due to the vagaries of rare bird species' occurrence which in any year are present in low numbers and therefore observed sporadically in some autumns: Common Crane, Griffon Vulture, Egyptian Vulture, Imperial Eagle, Golden Eagle, Red Kite, Saker Falcon, Lesser Kestrel and Eleonora's Falcon, Eagle, Dalmatian Pelican, and Lesser Kestrel.

One of the most sensitive species with respect to collision with turbines, according to the literature, the Griffon Vulture (*Gyps fulvus*) was observed once in autumn 2017. One reintroduced sub adult bird was observed on 09 October in the vicinity of SNWF. The bird was found in the field in bad physiological condition. Our field ornithologist provided food and captive care of the bird for next three days. The bird was identified as part of experimental reintroduction project. In coordination with the project leader Emilian Stoynov the bird was successfully traced in the area with wind turbines. For this period the TSS was applied in order to provide safe corridor for the bird (http://fwff.org/%D0%B1%D1%8A%D0%BB%D0%B3%D0%B0%D1%80%D1%81%D0%BA%D0%B8-%D0%B1%D0%B5%D0%BB%D0%BE%D0%B3%D0%BB%D0%B0%D0%B2%D0%B8%D1%8F%D1%82-%D0%BB%D0%B5%D1%88%D0%BE%D1%8F%D0%B4-%D0%BA4n-%D0%BE%D0%B1%D0%B5%D0%B4%D0%B8/)

Absolute counts 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 (primarily soaring water birds and birds of prey) in nine autumn seasons of pre-construction (2008) and post-construction years (2009 – 2017).

Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A. brevipes	95	210	976	290	94	650	138	190	334	89
A. chrysaetos			2	2	1	1	2			
A. cinerea	120	259	26	40	56	70	113	20	50	23
A. gentilis	10	6	5	11	22	38	9	16	4	3
A. heliaca	2							1		1
A. nisus	44	44	70	73	44	206	101	133	150	118
A. pennata	4	3	22	5	10	22	14	10	8	12
A. pomarina	44	9	80	76	31	1966	509	146	18	18
A. purpurea		59	11	1	7	3		2		
B. buteo	146	390	180	459	238	2345	1073	499	856	1530
B. oedicnemus		1		1						
B. rufinus	163	151	34	30	33	28	41	32	27	26
C. aeruginosus	327	268	341	271	179	473	298	339	165	383
C. ciconia	2998	87	24980	620	2525	11230	4639	292	1191	2017
C. cyaneus	5	1		1		3	18		3	8
C. gallicus	29	19	18	25	60	88	26	38	27	23
C. macrourus	8	27	18	4	7	7	15	8	2	11
C. nigra	8	8	8	1	13	488	48	29	25	42

Species	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
C. olor		1	3				2	11		
C. palumbus	10		1				26	2		12
C. pygargus	32	17	111	151	55	82	102	161	47	86
E. alba			1	1	5					
E. garzetta		7				11	1	33		
F. cherrug		7		2	1		1			
F. eleonorae	7			1	1		7			1
F. naumanni	1									
F. peregrinus		2	4	1	1	5	5	2	1	6
F. subbuteo	48	125	120	96	66	88	89	135	31	53
F. tinnunculus	138	357	45	120	67	103	89	108	86	81
F. vespertinus	11	180	1773	63	793	167	426	434	107	297
G. fulvus			1		1	2	1	1	1	1
G. grus						1		91	32	136
M. migrans	18	6	32	17	21	34	32	69	8	78
M. milvus			1	1		2	1	1		
N. percnopterus					1			2		
P. apivorus	58	76	1549	152	115	4284	113	258	55	287
P. crispus	4						5		21	
P. haliaetus	15	13	14	12	7	13	5	20	13	7
P. leucorodia	117	83	56	48		59		122	22	79
P. onocrotalus	120	1190	252	277	1700	3285	1679	2857	1527	1460
Ph. carbo	267	354	494	75	131		866	263	542	201
Ph. pygmaeus		19								
Pl. falcinellus	5	738								
St. hirundo		71								
T. tadorna		94			3					
T. ochropus		8			1	15				
T. glareola							3	11		
T. merula							80			2
T. viscivorus							17			
V. vanellus			1			7		7		1
Total	4854	4890	31229	2927	6288	25761	10594	6332	5353	7090
Number of species	30	35	32	32	31	31	36	34	28	31

The number of species as well as the absolute number of birds crossing the study area (Tables 1 and 2) did not decrease after the construction of turbines. The absolute number per year of the most numerous species of soaring migrants: White Pelican, White Stork, Levant Sparrowhawk, Common Buzzard, Honey Buzzard and Lesser Spotted Eagle widely varied in the ten study seasons (Fig. 3 & 4).

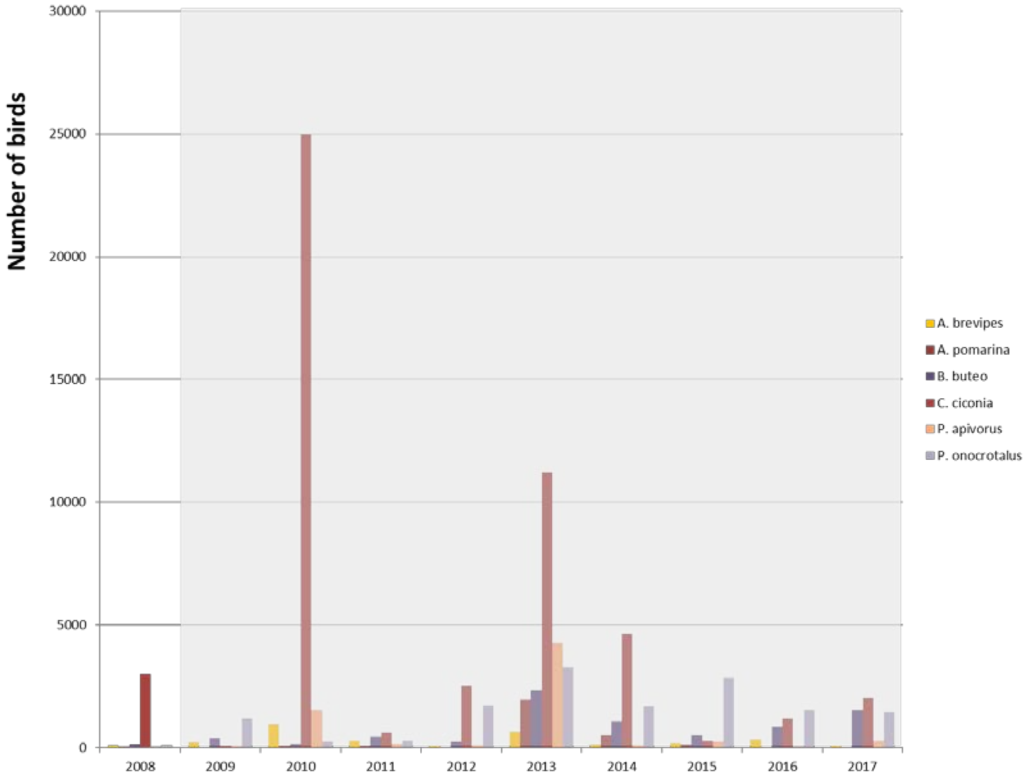


Figure 3. Variations in the total number of the most numerous soaring bird species observed during autumn migrations in ten years (pre-construction 2008, and post-construction periods - in background grey shading) in SNWF.

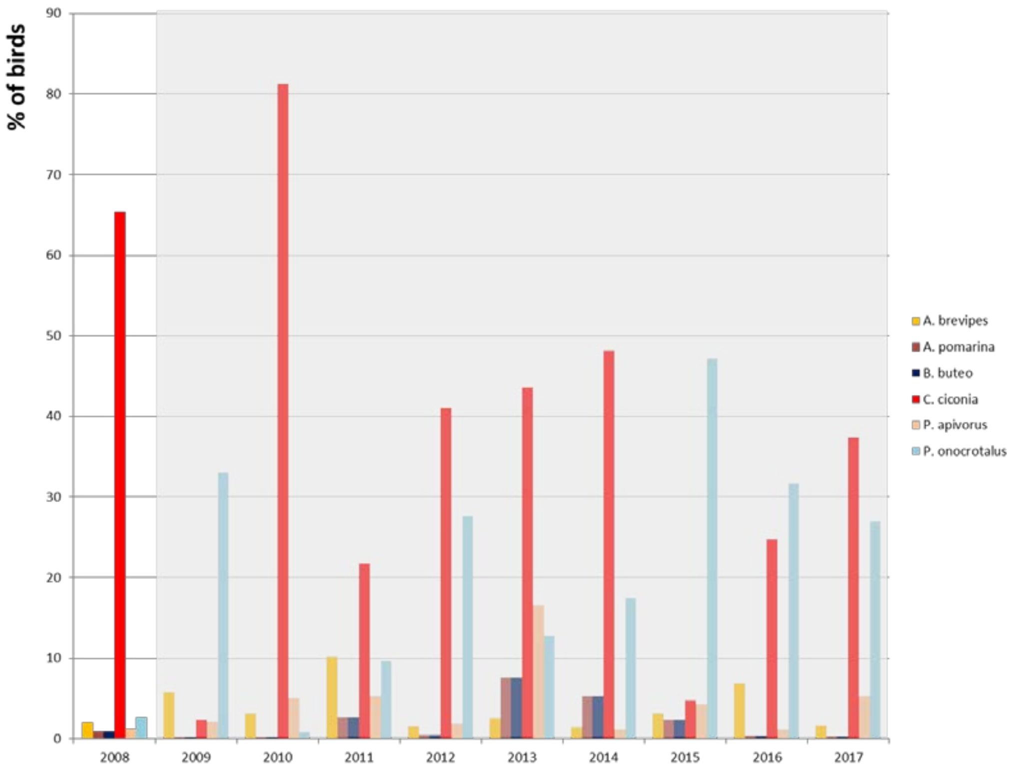


Figure 4. Percentage annual contribution of individual species (of the six most numerous soaring bird species recorded) to the total migratory traffic in and over SNWF in autumns 2008 – 2017 (pre-construction 2008, and post-construction periods - in background grey shading).

Another numerous group of migrants recorded at SNWF are species specialized in diurnal aerial foraging for insects. Not all birds of these species, bee-eaters, swifts and swallows (hirundines), crossing SNWF were detected because of their small size and methodological limitations of visual observations. The recording of these species highly depends on the distance from the observer (in both vertical and horizontal visual planes) because of their small size and, often their flight altitude (for details see autumn report 2013). Therefore visual observations on these species are limited to a few hundred meters and cannot be considered as absolute numbers and definitive counts for a given area and at all altitudes.

In autumn 2017 the number of Swifts (*Apus* spp.) was relatively lower (Table 3). In contrast the Barn Swallow (*Hirundo rustica*) and Bee-eater (*Merops apiaster*) were numerous compared to some previous autumn seasons in SNWF (Table 3). One possible explanation of the observed fluctuations between the different autumn seasons could be prevailing wind direction during the period of passage of aerial foraging birds drifting them closer to the Black Sea coast in some years.

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

Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A. apus	79	10	6	8	17	12	52	39	4	20
A. melba	515	16	536	234	47	127	58	26	8	50
D. urbicum	1007	697		180	3	170	109	436	25	20
H. daurica	2	8		4	1					
H. rustica	2979	4234	1735	164	5994	815	550	473	40	4800
M. apiaster	4625	3355	5024	2107	2733	5906	1828	1377	688	5156

Altitude of autumn migration

In order to test whether the construction of SNWF turbines has resulted in an increase of flight altitude of migrating birds we calculated the average altitude per year of all species of diurnal migrants regularly passing through SNWF in autumn, including 2017 (Table 4).

Table 4. Mean flight altitude (in meters above the ground level), by species, of diurnal migrants observed in SNWF across nine autumn seasons, 2008-2017: the years when the wind farm was constructed are highlighted in grey.

Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A. brevipes	132	171	171	160	142	263	188	178	175	157
A. cinerea	201	239	263	386	190	344	341	133	288	251
A. gentilis	181	176	230	199	151	267	232	146	65	103
A. nisus	150	135	162	141	119	204	124	139	170	77
A. pennata	150	283	251	213	295	261	368	213	255	213
A. pomarina	244	273	234	234	241	353	279	210	243	365
B. buteo	165	199	206	197	158	278	215	187	202	127
B. rufinus	109	200	230	183	147	211	177	156	165	113
C. aeruginosus	158	139	235	150	128	222	201	113	113	156
C. ciconia	199	174	434	347	358	390	279	242	296	221
C. cyaneus	136	100		10		267	70	100*	11	4
C. gallicus	256	144	258	242	218	229	269	221	190	208

Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
C. macrourus	251	90	240	195	86	188	150	98	53	148
C. nigra	462	325	375	350	388	382	330	339	260	268
C. pygargus	196	115	285	106	79	209	144	107	126	153
F. subbuteo	97	119	161	161	127	131	181	139	94	89
F. tinnunculus	49	96	109	70	79	67	85	40	55	47
F. vespertinus	106	106	224	289	121	139	156	197	226	183
M. migrans	175	183	166	152	233	243	179	213	236	161
P. apivorus	320	175	268	283	204	342	290	270	240	333
P. haliaetus	314	208	224	433	**	400	133	172	303	252
P. leucorodia	433	285	667	317		317		350	500	300
P. onocrotalus	100	159	417	400	265	263	271	230	275	252
Ph. carbo	180	179	277	271	254	265*	285	284	285	203

*Estimated value by observation of individuals which are identified with high probability as given species, but because of distance it can be misidentified and therefore is not presented in Table 1 and 2.

**The species is observed, but flight altitude data is missing for the season.

No trend in the fluctuations of average altitude of the most numerous soaring bird species was registered after ten years of autumn migration monitoring at SNWF, including one pre-construction and nine post-construction seasons. The comparative analysis showed that there was no significant change in average flight altitudes of the 24 most numerous soaring bird species regularly migrating through SNWF (Fig. 5).

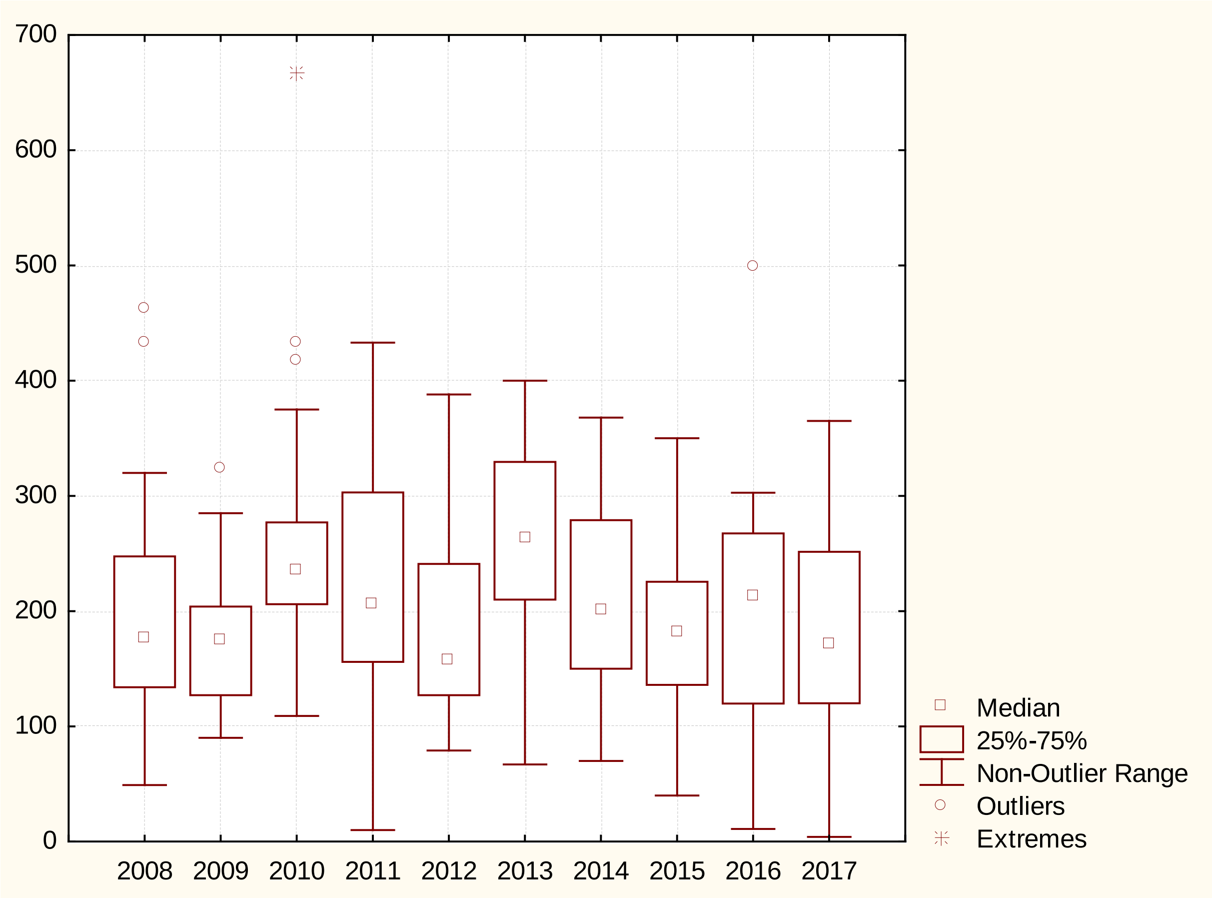


Figure 5. The median altitude of soaring bird migration observed from SNWF during autumns from 2008 to 2017, with measures of variance. The species included in the calculations are presented in Table 4.

Observed flight altitudes of Bee-eaters and Barn Swallows were analyzed despite the constraints on reliability imposed by visual observation, as previously noted. Nevertheless, despite the caveats on observational constraints (which should apply more-or-less equally across study years), it appeared that while the average observed flight altitude of bee-eaters and swallows varied widely across years there was no trend that could be attributable to the presence of SNWF (Table 5).

Table 5. Mean altitude (in m. above ground level) of flight during autumn migration of bee-eaters *M. apiaster* and barn swallows *H. rustica* in the period 2008 – 2017 observed in SNWF.

Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
H. rustica	28	51	66	19	37	32	35	35	50	45
M. apiaster	73	68	128	71	83	66	85	100	92	95

Changes in the flight altitude of soaring migrants, Bee-eaters and Barn Swallows have apparently had no consistent character across years and do not indicate any impact due to SNWF. Most probably climatic factors, conditions on the breeding grounds of these species that breed away from SNWF, and local aerial insect availability at the time of passage (for those species in Table 5) are likely to be responsible for the fluctuations in average altitude of autumn migration during the ten year monitoring period. 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 (Madsen et al. 2009, 2010) if they occur.

Direction of autumn bird migration

The mean recorded direction of the 24 species (listed in Table 4) is presented in Table 6. Prevailing directions of autumn migration observed in all ten autumn seasons 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 (i.e. excluding 2009 when the observation points were moved northward in order to test the TSS). The main direction in all years shows the guiding role of the coast line (see Fig. 1 and Table 7).

Table 6. Mean observed flight direction of autumn migration by species listed in Table 4, in different years. Directions are given in degrees starting from 0 (North).

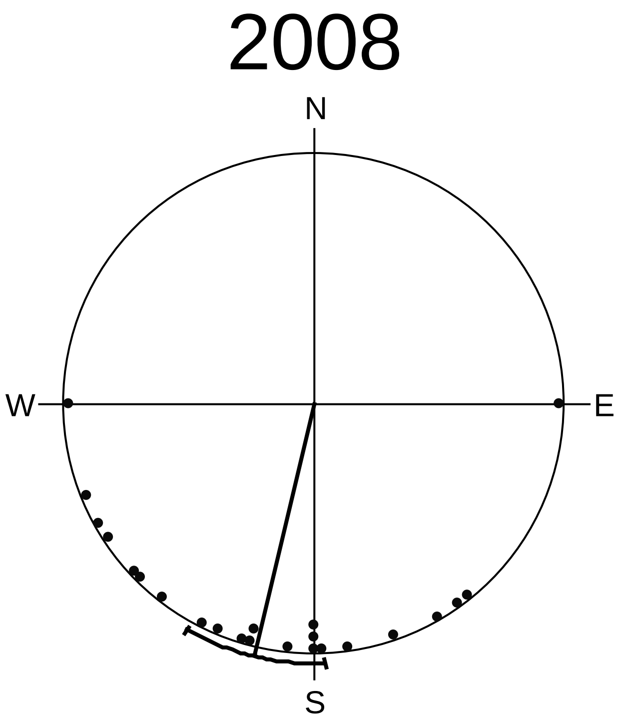
Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A. brevipes	172	151	185	175	179	191	156	161	166	193
A. cinerea	248	178	146	138	203	167	176	101	169	172
A. gentilis	195	162	171	180	149	181	163	188	90	15
A. nisus	218	155	186	193	174	185	164	164	174	187
A. pennata	180	150	182	165	216	184	212	198	128	200
A. pomarina	225	173	204	183	193	214	180	196	166	206
B. buteo	195	150	177	179	179	198	172	165	166	175
B. rufinus	150	158	227	186	188	158	119	185	169	116
C. aeruginosus	197	150	191	188	175	199	166	166	154	180
C. ciconia	207	154	209	210	209	216	181	215	206	170
C. cyaneus	90	180		225		188	180	135*	135	146
C. gallicus	203	150	144	151	129	159	142	165	130	140
C. macrourus	141	154	180	231	109	210	144	135	203	187
C. nigra	270	191	225	180	231	205	163	206	180	172
C. pygargus	237	148	182	183	174	194	154	165	165	173
F. subbuteo	186	148	174	196	196	188	157	156	157	189
F. tinnunculus	144	148	177	161	191	156	153	138	175	153
F. vespertinus	180	159	177	204	218	206	169	198	186	188
M. migrans	241	153	211	207	189	192	210	179	203	179
P. apivorus	227	187	201	200	208	204	174	195	176	201
P. haliaetus	161	190	168	198	169	199	152	135	168	147
P. leucorodia	180	173	195	180		180		162	180	180
P. onocrotalus		146	195	257	232	214	180	177	15	192
Ph. carbo	178	162	192	160	121	177*	155	154	132	158

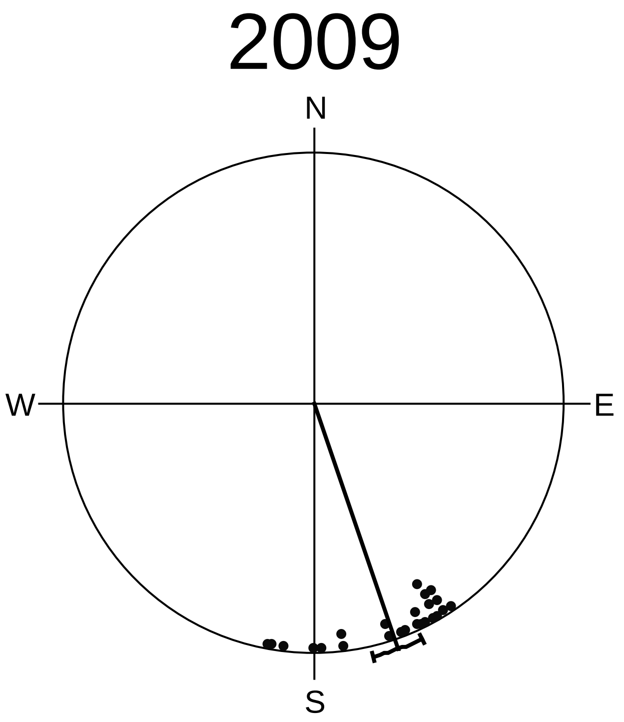
*Estimated value by observation of individuals which are identified with high probability as given species, but because of distance it can be misidentified and therefore is not presented in Table 1 and 2.

Table 7. Basic statistical parameters of empirical flight directions obtained from visual observations during ten autumn seasons in SNWF for the 24 'core' soaring bird species (listed in Table 4).

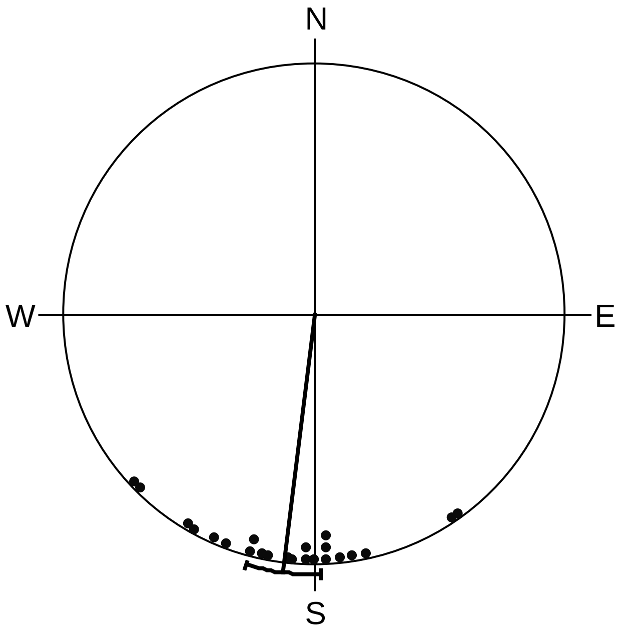
Autumn season	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number of species	23	24	23	24	22	23	23	23	24	24
Mean Vector (μ)	193°	161°	186°	188°	184°	190°	166°	168	164	174
Length of Mean Vector (r)	0,8	0,96	0,93	0,90	0,85	0,95	0,94	0,89	0,82	0,93
Concentration	2,7	16,6	8,4	5,5	3,7	11,8	8,8	5,1	3,2	7,5
Circular Variance	0,21	0,03	0,06	0,09	0,14	0,95	0,05	0,1	0,17	0,06
Circular Standard Deviation	39,3°	14,2°	20,2°	25,5°	32,3°	17,1°	19,8°	26,6	35,4	21,5

The circular (compass) distributions of flight directions of soaring birds are presented in graphs below for each year (Fig. 6).

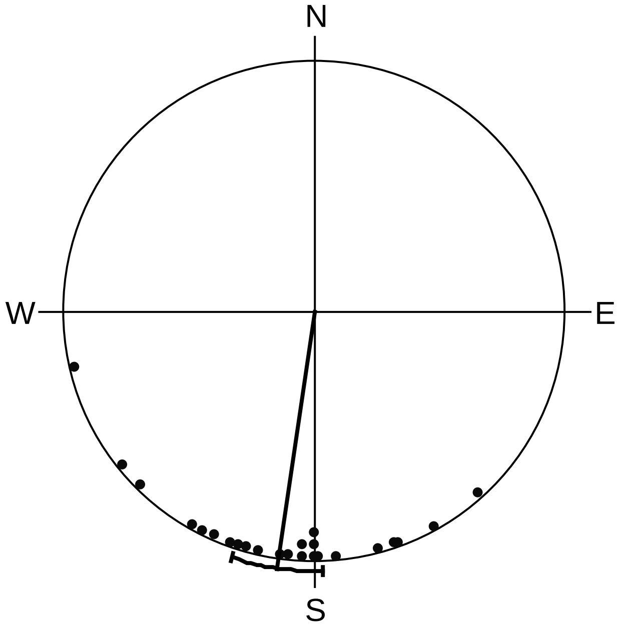




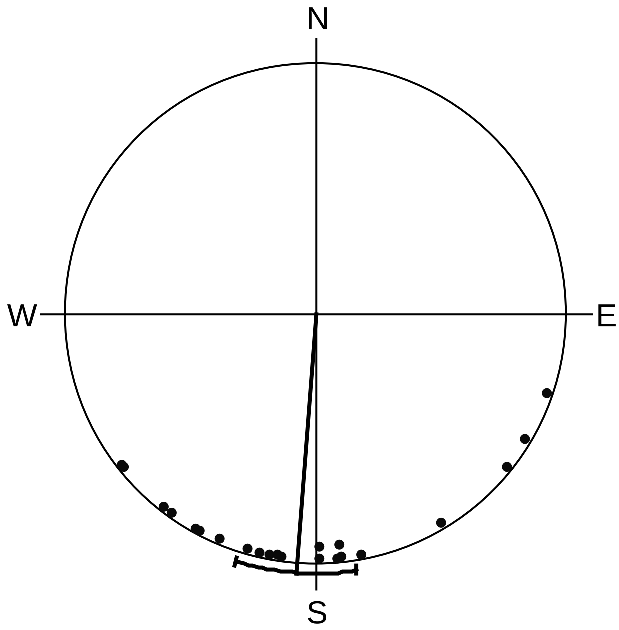
2010



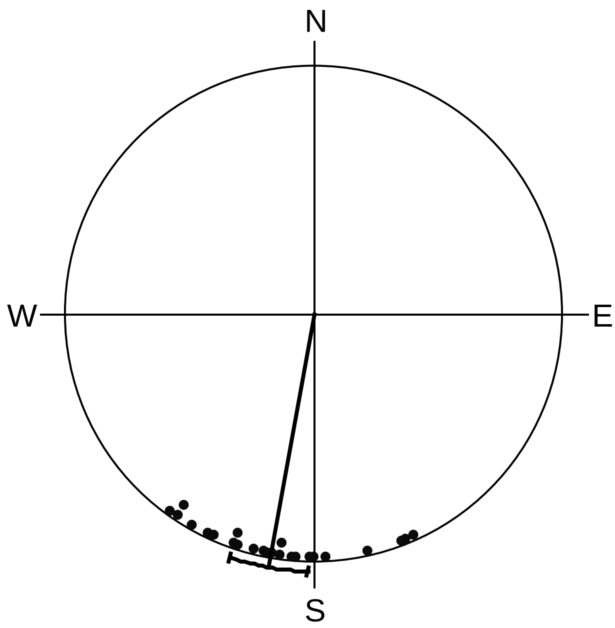
2011



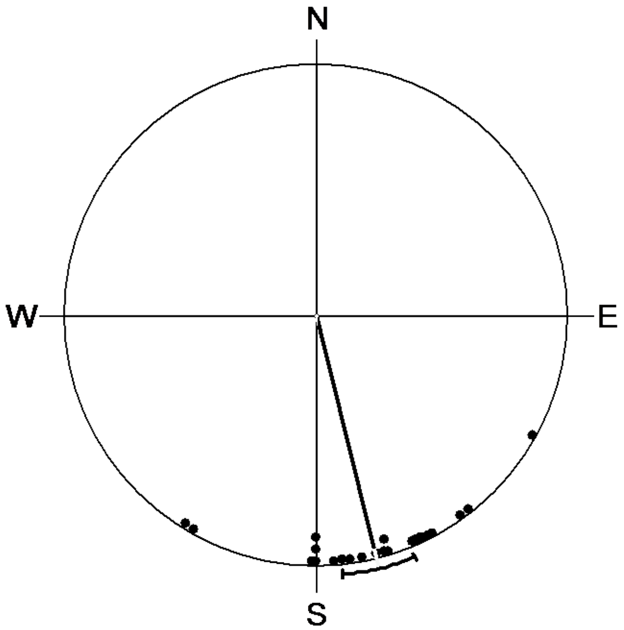
2012



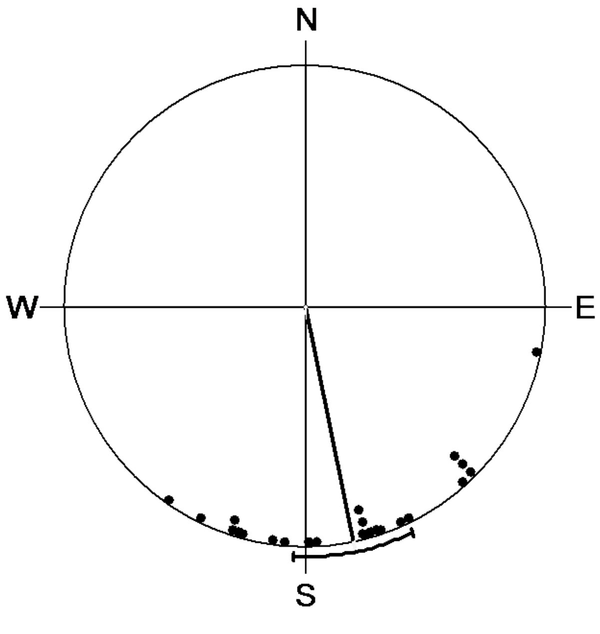
2013

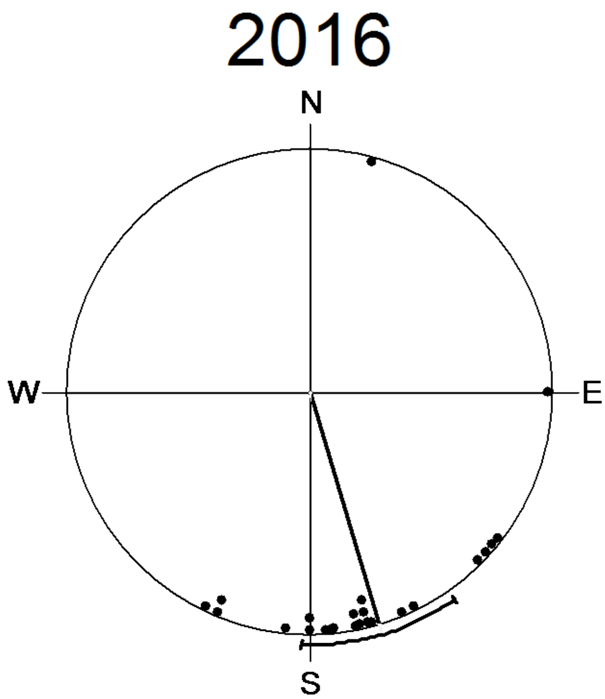


2014



2015





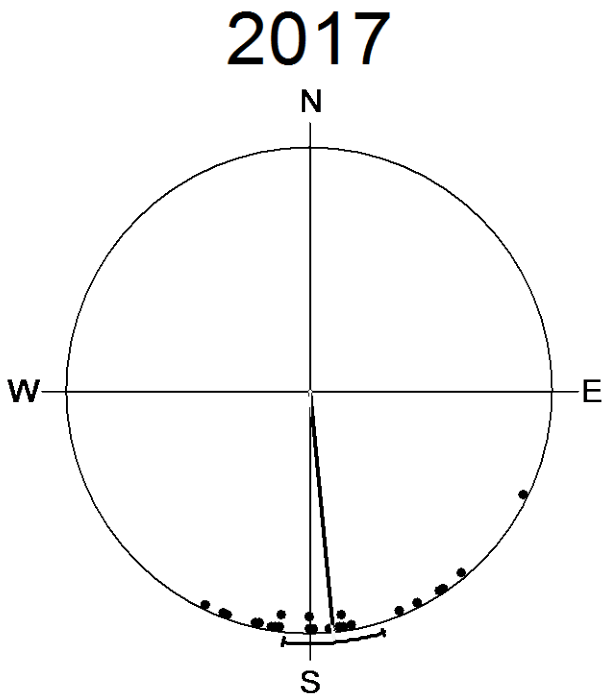


Figure 6. Graphical representations of the average flight directions of the 24 'core' soaring bird species by year: each record = 1 species (see Tables 4, 6 and 7). (In 2009, observation points were stationed further north than in other years.)

The direction of migration in 24 of the most common and numerous soaring birds observed at SNWF in the last ten years does not indicate any consistent annual deviation from the seasonal migratory direction after construction of SNWF (Table 7 and Fig. 6). An expectation, if the turbines were causing birds to avoid the study area would be that there should be a major shift in migratory direction much further to the west, as birds deflect inland and away from the wind farm. This has not been recorded.

In 2014, 2015, 2016 and 2017 the mean direction of the same most numerous species of soaring birds suggested that not only the location of observation points (as in 2009) but also some other factors (perhaps conspecific flock attraction and probably specific wind directions during the season) may also explain annual deviations from the typical direction of soaring bird migration across SNWF over the nine years of study.

Bearing in mind the feeding behavior of Bee-eaters and Barn Swallows which are specialized in hunting insects in the air during daytime, and the detailed analysis of flight directions in previous reports, it is also likely that several species' abundance may be governed by the capacity for feeding activity as well as active migratory flight through SNWF during autumn (Table 8).

Table 8. Mean flight directions of barn swallows *H. rustica* and bee-eaters *M. apiaster* as observed from SNWF across ten autumn seasons. Directions are given in degrees starting from 0 (North).

Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
H. rustica	158	144	204	169	172	150	101	68	Low number	172
M. apiaster	191	142	192	186	187	189	177	162	151	186

There is no evidence under the scale and form of analysis for a major directional change in the flight orientation behavior of autumn migrants (macro-avoidance) as a result of the wind farm operation. 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.

Spatial and temporal distribution of observed 'major' influxes of soaring migrants and Turbine Shutdown System

In autumn 2017, intensive soaring bird migration was observed mainly in the standard monitoring period 15 August – 30 September defined in previous reports with a peak period in September (Fig. 7). Prevailing wind directions in autumn 2017 were S-SW (Table 9). Again as in previous years, westerly winds, which bring periodic influxes of soaring migrants swept easterly from the main Via Pontica migration route (Fig. 1) were infrequent.

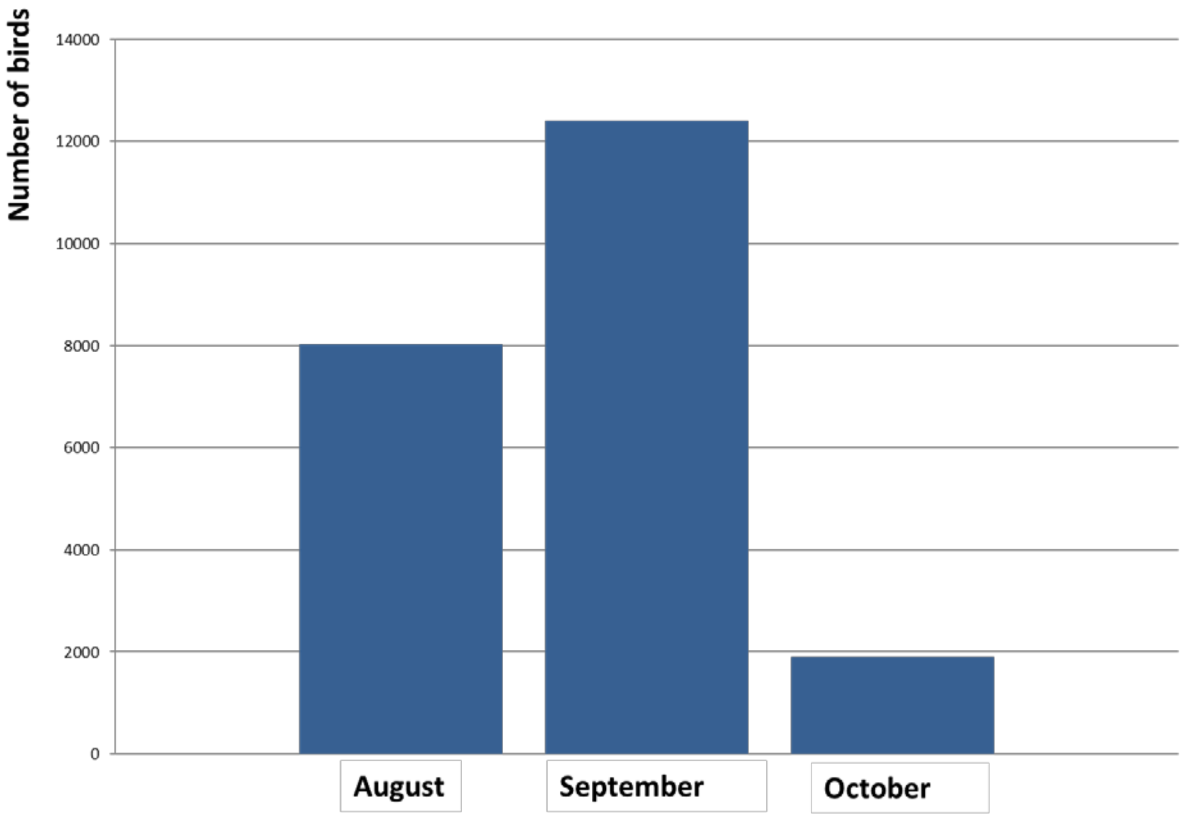


Figure 7. Monthly distribution of all registrations of migrating birds during the autumn season 2017.

Notable days with relatively strong migration of soaring birds at low altitudes were observed on 30 August with 400 White Pelicans (*Pelecanus onocrotalus*) and 04 and 05 September with 400 White Storks (*Ciconia ciconia*), respectively. Notable numbers were observed also on 13 September when 86 White Storks crossed the SNWF territory. All the events of turbine stops in respond to target bird species presence in SNWF are listed in Table 10.

Table 9. Number of birds (of most numerous soaring bird species: *B. buteo*, *C. ciconia*, *P. apivorus*, *P. onocrotalus*) and wind direction during the autumn 2017 monitoring period. For reference: a northerly wind direction = 0, and a southerly wind direction = 180.

Date	Number of birds	Wind direction
10.08	7	152
11.08	4	95
12.08	3	27
13.08	12	172
14.08	3	317
15.08	575	286
16.08r	14	188
17.08	21	201
18.08	27	209
19.08	12	98
20.08	4	130

Date	Number of birds	Wind direction
21.08	78	250
22.08	148	330
23.08	142	225
24.08	504	123
25.08	66	150
26.08	25	114
27.08	15	102
28.08	13	201
29.08	27	150
30.08	899	164
31.08	136	199

Date	Number of birds	Wind direction
1.09	20	185
2.09	3	194
3.09	8	152
4.09	1039	285
5.09	597	193
6.09	760	277
7.09	202	227
8.09	178	168
9.09	6	134
10.09	148	182
11.09	115	132

Date	Number of birds	Wind direction
12.09	210	209
13.09	1851	275
14.09	1475	210
15.09	148	184
16.09	14	172
17.09	29	101
18.09	10	187
19.09	14	88
20.09	97	145
21.09	24	291
22.09	242	263
23.09	67	249
24.09	227	227
25.09	63	61
26.09	11	56
27.09	39	34
28.09	10	34

Date	Number of birds	Wind direction
29.09	76	76
30.09	15	117
1.10	3	357
2.10	23	206
3.10	28	98
4.10	1	183
5.10	26	234
6.10	140	182
7.10	4	64
8.10	0	274
9.10	6	253
10.10	95	249
11.10	4	163
12.10	6	224
13.10	17	263
14.10	16	215
15.10	11	300

Date	Number of birds	Wind direction
16.10	5	192
17.10	5	226
18.10	107	115
19.10	32	188
20.10	15	191
21.10	6	171
22.10	4	209
23.10	2	114
24.10	10	74
25.10	295	275
26.10	478	282
27.10	6	221
28.10	3	287
29.10	75	244
30.10	147	271
31.10	210	283

Table 10. List of observed 'major' influxes of soaring migrants according to species, in autumn 2017 in or over SNWF, by date and the stop and start times of turbine shutdowns.

Date	Stop	Start	Species	Number of birds	Turbines stopped *	Ordered by
30.08.2017	09:12	09:43	White pelican	400	C,D,E	K. Peeva
30.08.2017	14:50	14:55	White pelican	1	F	S. Peev
04.09.2017	16:20	16:31	Black stork	5	E	S. Peev
04.09.2017	17:15	17:30	White stork	400	E	S. Peev
05.09.2017	09:35	09:39	White stork	80	F	K. Peeva
05.09.2017	08:52	09:10	White stork	400	E	S. Peev
13.09.2017	18:20	18:25	White stork	86	T14, T15	S. Peev
13.09.2017	18:20	18:25	White pelican	4	T14, T15	S. Peev
9.10.2017 г.	12:55	13:34	Griffon vulture	1	A,B,C,D,E, F	K.Bedev

* The turbines of SNWF are grouped in 6 clusters in respect to territory.

Our long term monitoring of autumn migration in SNWF has revealed an increase of 'soaring' birds in the days with westerly winds (see report autumn 2010 http://www.aesgeoenergy.com/site/images/Bird_Migration_autumn_2010.pdf). In order to perform statistical tests and evaluate significance of winds with west direction for observed increase in soaring bird numbers we have applied a statistical tests and corelative analysis. Results are presented in Fig. 8 and 9.

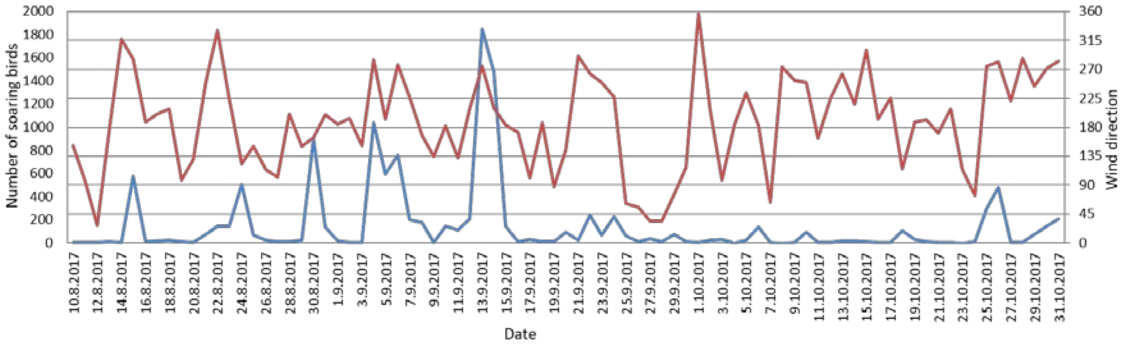


Figure 8. Number of soaring birds (blue line) and wind direction day by day (red line) in SNWF in autumn 2017.

Relatively lower numbers of soaring birds were observed in SNWF in autumn 2017 (for species and number of birds see Table 4) and were were concentrated in six days when prevailing winds were with a strong westerly component (Fig. 8). (The bird species included in this analysis are presented in Table 2.) These observations are in line with previous autumn seasons during preconstruction and operational periods of SNWF monitoring with an observed influence on soaring birds' presence by westerly winds. As also observed in previous years, not all periods when westerly winds occurred resulted in an influx of soaring migrants, but all such influxes were associated with westerly winds. This is probably because the passage of birds on the migration flyway to the east of SNWF does not always occur when a westerly wind occurs, as illustrated in previous reports (and later in this report).

The species composition of soaring birds in these six documented daily spikes of increased occurrence differed in autumn 2017, although all predominantly involved either White Storks, White Pelicans and/or Common Buzzards. White storks were most numerous in 3 of 6 days of intensive migration (15 August, 4 and 7 September, Fig. 8). White Pelicans dominated also in three of the observed days with westerly winds (22, 24 and 30 August). Common Buzzards dominated in two days towards the end of October (25 and 30 October).

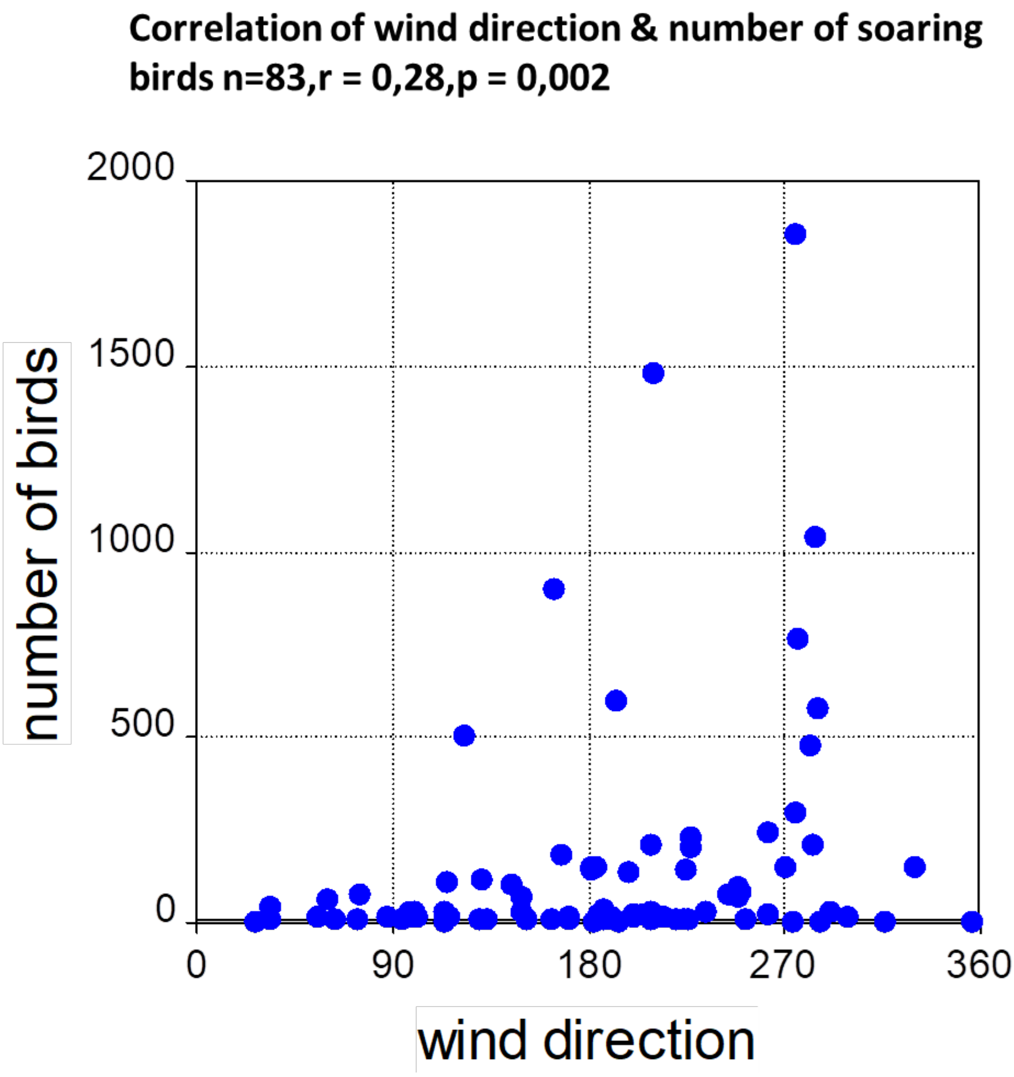


Figure 9. Plot distribution of observed daily number of soaring birds (n = 83) in respect to daily prevailing wind direction (0 = north, 270 = west), and correlation coefficient (r) for soaring bird number against wind direction, at SNWF in autumn 2017.

We undertook a circular-linear correlation between daily records of the total number of soaring birds (counts of the 24 soaring species) against the prevailing daily wind direction (Fig. 9). The correlation coefficient ($r = 0.28$) is significant statistically for the daily occurrence of a (westerly) wind direction and the daily count of soaring migrants ($p < 0.01$) (Fig. 9). In other words significantly higher numbers of ‘soaring’ migrants were associated with days when winds were more westerly and fewer migrants were seen when wind conditions deviated further from the west. While this result was strongly supportive of the role of the westerly winds in generating the presence of soaring migrants at SNWF, it should be noted that this is against a background of other factors which may militate against such a finding; and so not lead to a very strong relationship. For example, several of the species classed as ‘soaring’ are not entirely dependent on wind conditions for their migration and can, and do, engage in active flight (e.g. falcons *Falco* spp. and harriers *Circus* spp.). Also birds' migration phenology is involved: if no or few birds happen, for other reasons, to be actively engaged in migration on the main flyway to the west of SNWF then there will be few birds that westerly winds would guide eastwards to SNWF. We see this in the results for particular species (described above) when, for example, White Storks were not recorded in relatively large numbers on every day when there were westerly winds; but the key finding was that large numbers of White Storks were only recorded on days with westerly winds.

Despite these factors which may militate against a simple correlative approach illustrating a relationship between westerly winds and numbers of soaring migrants, these analyses from autumn 2017 data confirm previous data analyses from other years, presented in earlier reports (http://www.aesgeoenergy.com/site/Studies.html) indicating that SNWF is situated to the east of the main migratory flyway and so only occasionally hosts major numbers of migrants when -non prevailing- westerly wind conditions shift birds from the flyway. These numbers are consistently lower than stated by BSPB before SNWF was approved for operation.

Turning to collision risk and collision mortality: in all days with intensive bird migration when potentially sensitive species were present (Figure 8 & Table 10) the application of the Turbine Shutdown System (TSS) probably contributed to a reduced risk of collision, and provided a safety mechanism to reduce collision risk for single birds and flocks of endangered or sensitive bird species (Table 10). Documentation of searches for collision victims during autumn 2017 are considered next.

Collision victim monitoring

After two trials for carcass removal and efficiency of the carcass searches in autumn, described in detail in the report for autumn 2014 (http://www.aesgeoenergy.com/site/tcs%20(33).html), a frequency of seven days between searches was defined as optimal to provide objective and cost-effective information about the number of bird collisions with turbines of SNWF.

The numbers of turbines searched during every autumn of operational period of the wind farm are presented in Table 11. The increase of total searches in autumn 2014, 2015, 2016 and 2017 was due to the increased monitoring period, until the end of October.

Table 11. Number of carcass searches per autumn under turbines in the operational period of SNWF.

Turbine №	**Autumn 2010**	**Autumn 2011**	**Autumn 2012**	**Autumn 2013**	**Autumn 2014**	**Autumn22 015**	**Autumn 2016**	**Autumn 2017**	**Total searches**
8	6	8	8	10	13	14	16	13	**88**
9	6	8	7	10	12	13	14	14	**84**
10	6	7	10	10	14	13	13	13	**86**
11	6	7	9	11	17	14	12	13	**89**
12	6	10	9	11	19	13	13	16	**97**
13	6	9	9	9	17	14	13	14	**91**

Turbine №	Autumn 2010	Autumn 2011	Autumn 2012	Autumn 2013	Autumn 2014	Autumn22 015	Autumn 2016	Autumn 2017	Total searches
14	6	9	7	10	15	13	14	14	**88**
15	6	9	7	10	15	13	13	14	**87**
16	6	6	9	10	15	13	12	13	**84**
17	6	6	9	12	13	13	14	15	**88**
18	6	4	8	12	14	13	14	15	**86**
19	6	8	9	12	15	12	13	15	**90**
20	6	9	10	12	14	15	13	13	**92**
21	1	6	8	10	16	14	13	13	**81**
22	6	6	8	13	14	15	14	13	**89**
23	6	6	8	10	18	13	15	13	**89**
24	6	7	7	10	16	14	15	13	**88**
25	6	2	8	9	16	13	18	13	**85**
26	6	8	8	13	13	14	13	13	**88**
27	6	2	8	11	14	15	12	13	**81**
28	6	2	5	12	13	15	13	13	**79**
29	6	8	7	10	16	17	16	14	**94**
31	1	9	7	11	15	14	13	14	**84**
32	6	9	8	11	15	15	13	13	**90**
33	6	8	7	9	18	14	13	13	**88**
34	6	8	7	10	15	15	13	14	**88**
35	7	8	7	10	15	14	13	14	**88**
36	6	9	7	10	13	13	14	13	**85**
37	6	9	9	13	15	14	13	15	**94**
38	6	9	6	10	14	12	14	13	**84**
39	6	8	7	10	16	14	15	13	**89**
40	6	7	8	9	16	16	15	13	**90**
41	6	7	6	11	18	14	14	13	**89**
42	7	7	7	10	15	14	15	13	**88**
43	11	9	7	10	15	14	15	13	**94**
44	11	7	7	10	15	15	15	14	**94**
45	6	8	8	10	13	14	10	13	**82**
46	6	9	8	10	14	14	15	14	**90**
47	6	9	7	10	15	16	14	14	**91**
48	6	9	7	10	14	15	15	14	**90**
49	6	10	7	13	14	13	13	14	**90**
50	6	10	7	11	15	14	15	14	**92**

Turbine №	Autumn 2010	Autumn 2011	Autumn 2012	Autumn 2013	Autumn 2014	Autumn22 015	Autumn 2016	Autumn 2017	Total searches
51	6	9	7	9	14	13	14	13	**85**
52	6	9	5	9	15	13	16	13	**86**
53	6	9	6	10	13	13	16	14	**87**
54	6	8	7	8	15	14	15	15	**88**
55	6	9	7	10	18	14	15	14	**93**
56	6	8	7	9	14	14	15	13	**86**
57	6	9	7	8	14	14	17	13	**88**
58	6	9	7	9	14	15	14	13	**87**
59	7	9	7	9	16	14	13	14	**89**
60	6	9	7	11	15	14	16	14	**92**
Total	**315**	**404**	**389**	**537**	**777**	**725**	**731**	**707**	**4585**

Because of technical maintenance and consequent limited access some turbines were not searched with equal frequency, but as these turbines were not operational in this time period around such maintenance then respective collision risk would be accordingly lower.

Under this search regime during the 2017 autumn migration period, 14 sets of remains were found that could be attributed to collision with turbine blades. The number of birds found dead under turbines in 2017 and the species' conservation status according to the Bulgaria Red Data book and IUCN are presented in Table 12.

Table 12. Collision victims recorded in autumn 2017.

English name	Latin name	Number of carcasses	Bulgarian Red Data book	IUCN
Common Swift	*Apus apus*	4	Not listed	Least Concern
Yellow-legged gull	*Larus michahellis*	3	Not listed	Least Concern
Chiffchaff	*Phylloscopus collybita*	1	Not listed	Least Concern
Willow warbler	*Phylloscopus trochilus*	1	Not listed	Least Concern
Common moorhen	*Gallinula chloropus*	1	Not listed	Least Concern
Grey partridge	*Perdix perdix*	1	Not listed	Least Concern
Red-backed shrike	*Lanius collurio*	1	Not listed	Least Concern
Red-breasted flycatcher	*Fucedula parva*	1	*Vulnerable	Least Concern
Scops owl	*Otus scops*	1	Not listed	Least Concern

*Bulgaria falls within the southern periphery of the breeding area of this species in southeastern Europe and most probably for this reason its numbers in different years vary (http://e-ecodb.bas.bg/rdb/en/vol2/Fialbico.html)

Table 13. The number of carcasses attributable to collision with wind turbines found during autumn migration between 2010 and 2017 in SNWF. For further details see Methods and reports on the autumn migration period in previous years.

Species	Carcasses attributable to collision	Conservation status according to IUCN (IUCN 3.1)
Alauda arvensis	3	Least Concern
Apus apus	7	Least Concern
Ardea purpurea	1	Least Concern
Acrocephalus palustris	1	Least Concern
Buteo buteo	1	Least Concern
Crex crex	1	Least Concern
Delichon urbicum	3	Least Concern
Garrulus glandarius	1	Least Concern
Gallinula chloropus	1	Least Concern
Gyps fulvus	1	Least Concern
Falco tinnunculus	2	Least Concern
Falco vespertinus	1	Near Threatened
Fucedula parva	1	Least Concern
Hirundo rustica	2	Least Concern
Lanius collurio	3	Least Concern
Larus ridibundus	1	Least Concern
Larus michahellis	9	Least Concern
Muscicapa striata	1	Least Concern
Oreolus oreolus	1	Least Concern
Otus scops	1	Least Concern
Perdix perdix	1	Least Concern
Pica pica	1	Least Concern
Phylloscopus collybita	1	Least Concern
Phylloscopus trochilus	1	Least Concern
Sylvia atricapilla	1	Least Concern
Sturnus vulgaris	1	Least Concern
Regulus regulus	1	Least Concern
27 species	**49**	**26 LC/1 NT**

IUCN criteria were used for evaluation of bird conservation status because of the unknown origin of migratory populations in autumn when the movements of birds found dead can cover different continents. National criteria for the same species would be applicable for breeding populations of the same species in the breeding period in spring. The mortality at SNWF for eight autumn seasons of carcass searches, typically under every turbine every week, cannot be remotely considered influential for the populations of any of the affected species.

CONCLUSIONS

Additional data collected in the autumn 2017 by standard methods were consistent with and comparable to previous years' efforts, and confirmed the previous results and allowed continued evaluation of the long term effect of SNWF on bird migration. The long term monitoring in the same area has allowed the following conclusions:

1. The numbers of species passing through the SNWF territory in autumn varied by year with no trend for a decrease after SNWF was constructed and started its operation (Table 1).

2. The absolute number of observed birds naturally varied by year but with no trend for a decrease after SNWF was constructed and started its operation (Table 2).

3. The altitude of flight varied by years but with no overall trend for an increase after SNWF was constructed and started its operation (Table 4 and Fig. 5).

4. There is no evidence for change in migratory direction (macro-avoidance or displacement) associated with the wind farm. 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 (Tables 6, 7, 8 and Fig. 6).

5. The occurrence of autumn migrants in all ten autumn seasons was strongly correlated with typically short periods of a few days when strong westerly winds occurred and deflected birds eastwards from the main migration corridor (Via Pontica) further to the west.

6. During eight years of wind farm operation, carcass searches during the autumn periods revealed a total of 49 collision victims involving 27 species of birds.

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

8. The application of the Turbine Shutdown System (TSS) may have made a contribution to the low level of direct mortality registered in the operational period of SNWF for several species identified as being sensitive to collision. Although not formally analysed, micro avoidance of turbine blades also appears to be very high, despite an apparent lack of macro avoidance of the wind farm. Even in the absence of TSS and micro avoidance, however, it is highly unlikely that the pre-construction predictions of mortality would have been observed, in large part because these predictions were based on inflated estimates of the numbers of migrants that "occur" at SNWF.

9. The substantial data collected in eight autumn seasons indicate that the operation of SNWF does not constitute an obstacle or threat, either physically or demographically, to populations of migrants passing through its environs.

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