NatureScot Information Note

The Effect of Aviation Obstruction Lighting on Birds at Wind Turbines, Communication Towers and Other Structures

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Disclaimer: this paper does not attempt to summarise all the literature on the effects of lighting and lit structures on birds. There are many, better reviews which can be sourced through various web based library searches. This information note seeks to focus on lights that are required for structures such as wind turbines, their potential to affect birds and mitigation methods.

Background

Artificial light is known to have many effects on birds which may be positive (increased opportunity for activity that would normally only occur during daylight); and negative effects, including attraction to lights (phototaxis), disruption of photoperiodicity and increased opportunities for visually active predators. However the principal effect discussed in this guidance note relates to phototaxis. It has been known for many years that birds are often attracted to lights, at lighthouses, buildings, offshore oil and gas platforms and urban street and building lighting (Gauthreaux *et al.* 2006, Manville *et al.* 2009, Ronconi *et al.* 2015). Attraction to lights is especially true of some taxonomic groups (e.g. some burrow nesting seabirds) and many nocturnally migratory species (especially passerines). Montevecchi (2006) describes in detail effects and impacts of lighting on marine birds. The reasons for such attraction are poorly known, though some authors posit navigation by moonlight or (for some seabirds) attraction to phosphorescence. Moreover it is often juvenile birds that are predominantly affected (Rodriguez *et al.* 2016, Miles *et al.* 2010). For others, a popular current working hypothesis is that artificial light interferes with the magnetic compass of the birds, one of several orientation mechanisms which may be especially important during overcast nights (Poot *et al.* 2008).

The consequences of attraction to lights can be catastrophic and involve mass kills of nocturnally migrating passerines, for example at lighthouses, oil & gas platforms, in towns and cities, and at communication towers. The consequences for the viability of bird populations are less well understood, though for many migratory species, mortality during migration is a significant proportion of annual adult and juvenile mortality, regardless of the additional effect of artificial lighting. For some species of petrel and shearwater, their conservation status may be threatened by attraction to towns and cities, as they become grounded and will fall victim to predators or traffic accidents (Rodriguez *et al.* 2015, Deppe *et al.* 2017). At guyed communication towers collision with guy wires can lead to significant kills (Longcore *et al*. 2008, 2012, 2013). It is widely agreed that collision risks are elevated on moonless nights, during poor weather including fog or mist (Avery *et al.* 1977, Drewitt & Langston, 2006) though kills can occur under almost any conditions.

Purpose

The purpose of this note is to discuss the likely effects on birds of lights that are placed on wind turbines to avoid risks to aviation.

The impacts of wind farms on birds has been widely discussed and the dominant effects are known, though the magnitude of effects is still subject to much uncertainty. The effect of lighting has received relatively little attention though the potential for this to act as an attractant, thus increasing the risk of collision, could become an issue that requires assessment in some situations. The urgency of this issue arises as wind turbines increase in height and as such require lighting under Civil Aviation Authority (CAA) rules (CAP 764, 2016). All wind turbines of greater than 150m in height require visible, red aviation lights as set out in CAP 764.

Bird Collisions at Lit Turbines, Towers and Communication Masts

There is little published literature on the impact of lights on wind turbines on birds, so the literature search was expanded to include communication towers and meteorology mats. However, as much of the literature on collisions with these structures relates to communication towers, so caution should be exercised when extrapolating risk to wind turbines, as communication towers and other masts are often stabilised using wire guys which present a significant risk of collision to birds flying nearby. Furthermore, most of the published research has been undertaken in the United States, though attention has also been paid to wind farms in the offshore environment off the coast of Europe. There is almost no literature of significance from the United Kingdom and in general monitoring of collisions by birds with man-made structure has received a lot less attention in UK compared to the US. A recent review of communication tower mortality in the US (Longcore *et al.* 2012, 2013) has shown that mortality can be significant at nocturnally lit communication towers, but the majority of such mortality is that of Neotropical migrants. Only about 2.6% of observed mortality were of species from taxa other than passerines. While the location of communication towers may mean that some groups (such as seabirds on offshore islands) could be under-represented in these figures, it is likely that collision risk at lit turbines for non-passerine taxa are likely to be relatively low in general.

Monitoring of migration kills at towers in the US has been undertaken on a number of occasions, investigating specific factors such as the nature of lighting (colour); whether steady, flashing or strobe lights are used; and their position (altitude) on towers. Kerlinger *et al.* 2010 studied night migrant fatalities at 30 wind farms in North America. Fatalities ranged from less than one fatality per turbine per year to approximately seven fatalities per turbine per year. Multi bird fatalities (defined as more than three birds per night) were rare. Most wind farms had FAA[1] approved aviation lights, though not all turbines are lit. In Europe onshore turbine fatalities have been estimated as being about 2-60 per turbine per year, but mortality of nocturnally migrating songbirds at offshore wind farms may be as high as 100-1,000 per turbine per year (Blew 2013)[2]. These totals are potentially significant in population terms, especially as the number of offshore wind farms grow. Huppop *et al.* (2006) showed that brightly lit turbines in the German Bight could cause high collision rates in poor weather. Ballasus *et al.* (2009) suggested that onshore turbines tend to have higher collision rates of birds at illuminated wind farms than unlighted facilities. Welcker *et al.* (2017) showed that nocturnal migrants were at no greater risk of collision than diurnal species at four onshore wind farms along a major migration route, but importantly, the turbines were *not* lit.

For communication towers Gehring *et al.* (2009) showed that such towers when lit caused significant bird kills, but that the nature of the light heavily influenced bird mortality. Indeed Gauthreux & Belser (2006) showed that birds were attracted to some lit towers but not others, with colour and mode of operation the determinant factors. Studies with radar have shown that birds left a tower that they had been drawn to upon switching lights off (Larkin & Frase (2006).

While the likelihood that burrow nesting seabirds will to show an elevated risk of collision with lit turbines has not been established, the fact that these species are attracted to lights (particularly juveniles), suggests that burrow nesting seabirds could also be susceptible. Based on an assessment of the published literature, the principal susceptible species are likely to be:

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[1] Federal Aviation Authority.

[2] It isn't clear where or how this estimate was arrived at.

1. Burrow nesting seabirds (i.e. petrels, shearwaters and Atlantic puffin);
2. Nocturnally migrating passerines.

For other species, especially resident breeding birds, there is little published evidence which suggests that lights on turbines are likely to present an existential risk to the viability of species populations, at any spatial scale.

Colour and Mode of Lighting

Lit structures are known to affect bird behaviour. For example Evans *et al*. (2009) concludes that artificial lighting at or just above ground level changes the behaviour of migrating birds. This might be due to birds changing migratory routes, flying at lower altitudes or remaining longer over lit areas.

Observational work has also looked at the influence of colour and mode (steady, flashing or strobe) on collision risk. Gehring *et al.* (2009) looked at a range of lighting arrangements and showed that white, stroboscopic lights attracted fewest birds compared to red flashing lights and steady red lights. A review by Kerlinger & Kerns (2003) showed that no large-scale fatalities occurred at wind energy developments where there were red-flashing lights installed whereas steady burning red lights showed the strongest attraction of migrants. Flashing red lights reduced attraction and subsequent kills significantly. White lights appear to be better than red lights (birds appear to show an attraction to red light). Towers with no lighting were least attractive. Kerlinger *et al.* (2010) also showed that steady red lights on turbines were more attractive to birds than flashing red lights.

Gehring *et al.* (2009) further suggested that it is the mode - flashing vs. non-flashing, steady lights - that is the principal factor that increases collision and that colour may be a secondary consideration. It has been hypothesised that red lights interfere with magnetoreception (Gauthreux & Belser, 2006, Manville 2009) in migrating birds. When skies are clear birds may be able to use stars to navigate; in cloudy or foggy conditions such cues are not available, which may explain why birds are more likely to collide with towers and turbines during foggy/cloudy nights.

Turbine Height

In general taller structures cause more fatalities than shorter structures. The reason for this is simple: migratory birds fly at altitudes generally greater than 100m so taller structures are more likely to intercept passage migrants. It is also known that migratory birds may lose height during foggy or overcast conditions, which may bring flocks previously flying above turbine height into the collision risk zone (Avery *et al.* 1977, Huppop *et al.* 2006).

Literature Review of Mitigation Methods

Mitigation approaches in the US have involved removal of steady red lights, replacing them with flashing red lights and sometimes, increasing the spacing of lights i.e. reducing the number of lights at operational wind farms and other towers (Manville 2009). Such measures have been shown to reduce but not eliminate collisions with migratory birds. In contrast to FAA (2015), CAA (2016) regulations [CAP764] only permits steady burning red lights on turbines (though do not require lights on blade tips).

Green down-lights have been adopted on some offshore platforms. Green lights appear to be less attractive to birds and down-lighting shields bright light from most nocturnally flying birds (Poot *et al.* 2008).

Shielding light from upward transmission reduces mortality of Newell's shearwaters in Hawaii (Reed *et al.* 1985).

An alternative approach is to only switch lighting on when aircraft are near. There are a number of systems that react when aircraft approach an operational turbine. For example, the Obstacle Collision Avoidance System (OCAS) is designed to alert pilots if their aircraft is in immediate danger of flying into an obstacle. OCAS uses a low power ground based radar to provide detection and tracking of an aircraft's proximity to an obstacle such as a power line crossing, telecom tower or wind turbines. This capability allows the visual warning lights to remain passive until an aircraft is detected and known to be tracking on an unsafe heading. This leaves the night-time sky free of unnecessary light thus decreasing public annoyance issues, and limiting situations where bird-strike may occur.

OCAS is currently the only FAA approved Audio Visual Warning System (AVWS) approved in the US National Airspace. OCAS is also the only AVWS approved by the International Dark Sky Association. OCAS is currently only operational in the US, Canada, Norway and Germany. Use of proximity induced lighting does appear to be permitted under CAP764 although we understand that the CAA now support its use in principle[3]

A number of mitigation options exist and these are listed in the table below, though note that mitigation options are evolving rapidly. Current options (July 2020) include:

Mitigation option	How it works
Flashing lights vs. steady lights	Flashing lights are believed to be less attractive to birds than steady lights.
White (or green) lights	White (or green) lights are believed to be less attractive to birds than red lights, which may affect nocturnal migrant navigation.
Directional intensity / shielding of lights	Already set out in ICAO requirements and EASA CS-ADR-DSN Chapter Q. This focusses the 2000 cd lighting in the horizontal plane (+ or – a few degrees) and reduces the intensity of the light from above and below. Both regulations stipulate minimum requirements as well as additional recommended vertical angles, which cannot be ignored without justification. Most lights on the market will incorporate this as standard.
Reduce intensity of lights from 2000 to 200 cd	Already set out in CAA guidance CAP 764. Lights can be dimmed to 200 cd in good visibility (greater than 5km). SNH note that 200 cd lights can still be visible to people at greater than 20km in good visibility conditions. The effectiveness for reducing bird collisions is unknown.
Selected turbine lighting or no turbine lighting	It may be acceptable to only light certain turbines (as agreed at Viking wind farm for example), or none of the turbines, on the basis of an aeronautical study (as provided for in ICAO Annex 14), subject to CAA approval on a case by case basis.

[3] Presentation from Andy Wells from the CAA at aviation lighting workshop in Nov 2019

Radar activated lighting	CAA support this in principle and are considering the parameters in detail. In the meantime CAA are happy to discuss the approach on a case by case basis. In use in other countries, to differing extents, but it is acknowledged that the costs are high.
Micro siting and turbine height	The need for lights can also be avoided through careful wind farm design and the use of smaller turbines (less than 150m).

References

Avery, Michael, Paul F. Springer, and J. Frank Cassel. (1977) Weather Influences on Nocturnal Bird Mortality at a North Dakota Tower. *The Wilson Bulletin* **89**, no. 2: 291-99. www.jstor.org/stable/4160911 .

Ballasus, H., K. Hill & O. Hüppop (2009): Artificial light as a threat for birds and bats. *Ber. Vogelschutz* 46: 127–157

Blew, J. 2013 Offshore obstruction lighting - Issues and mitigation. Conference on Wind power and Environmental impacts: Stockholm 5-7 Feb 2013. Downloaded at this link (24th February 2017)

CAA (2016) CAP 764: Policy and Guidelines on Wind Turbines. (Downloaded at this link 6th July 2019)

Deppe, L., Rowley, O., Rowe, L.K., Shi, N., McArthur, N., Gooday, O., Goldstien, S.J. (2017) Investigation of fallout events in Hutton's shearwaters (*Puffinus huttoni*) associated with artificial lighting. *Notornis* 64 (4): 181-191.

Drewitt, A.L. & R.H.W. Langston. 2006. Assessing the impacts of wind farms on birds. *Ibis* 148: 29– 42.

Evans, W. R., Y. Akashi, N. S. Altman and Manville, A. M. II. (2007) Response of night-migrating songbirds in cloud to coloured flashing light. *North American Birds* 60: 476 – 488.

FAA (2015) Obstruction Marking and Lighting. Advisory Circular with Change 2. (Downloaded link on 6th July 2020)

Gehring, J. L., Kerlinger, P. K. & Manville, A. M. II 2009. Communication towers, lights, and birds: successful methods of reducing the frequency of avian collisions. *Ecological Applications* 19: 505–514.

Gauthreux, J. R., & Belser, C.B. (2006) Effects of artificial night lighting on migrating birds. Pages 67–93 in: *Ecological consequences of artificial night lighting* (C. Rich and T. Longcore, Editors). Island Press, Washington, D.C., USA

Huppop, O., Dierschke, J., Exo, K.-M., Friedrich, E. and Hill, R. (2006), Bird migration studies and potential collision risk with offshore wind turbines. *Ibis*, 148: 90–109. doi:10.1111/j.1474-919X.2006.00536.x

Kerlinger, P., Joelle L. Gehring, Wallace P. Erickson, Richard Curry, Aaftab Jain, and John Guarnaccia (2010) Night Migrant Fatalities and Obstruction Lighting at Wind Turbines in North America. *The Wilson Journal of Ornithology*, **122** (4): 744-754.

Kerlinger, P. and J Kerns (2003) FAA lighting of wind turbines and bird collisions. Presentation at the NWCC Wildlife Working Group.

Larkin, R. & Frase, B. F. 1988. Circular paths of birds flying near a broadcasting tower in cloud. *Journal of Comparative Psychology* **102**: 90–93.

Longcore, T., Catherine Rich, Sidney A. Gauthreaux, Jr., Height, Guy Wires, and Steady-Burning Lights Increase Hazard of Communication Towers to Nocturnal Migrants: A Review and Meta-Analysis, *The Auk*, Volume 125, Issue 2, 1 April 2008, Pages 485–492, https://doi.org/10.1525/auk.2008.06253

Longcore T, Rich C, Mineau P, MacDonald B, Bert DG, Sullivan LM, et al. (2012) An Estimate of Avian Mortality at Communication Towers in the United States and Canada. *PLoS ONE* 7(4): e34025. https://doi.org/10.1371/journal.pone.0034025

Longcore, T., Catherine Rich, Pierre Mineau, Beau MacDonald, Daniel G. Bert, Lauren M. Sullivan, Erin Mutrie, Sidney A. Gauthreaux, Michael L. Avery, Robert L. Crawford, Albert M. Manville, Emilie R. Travis, David Drake (2013) Avian mortality at communication towers in the United States and Canada: which species, how many, and where? *Biological Conservation*, 158, 410-419 https://doi.org/10.1016/j.biocon.2012.09.019

Manville, A.M., II. 2009. Towers, turbines, power lines, and buildings –steps being taken by the U.S. Fish and Wildlife Service to avoid or minimize take of migratory birds at these structures. In C.J. Ralph and T.D. Rich (editors). Proceedings 4th International Partners in Flight Conference, February 2008, McAllen.

Miles, W. Sarah Money, Richard Luxmoore & Robert W. Furness (2010) Effects of artificial lights and moonlight on petrels at St Kilda, *Bird Study*, 57:2, 244-251, DOI: 10.1080/00063651003605064

Montevecchi, W A (2006) Influences of artificial light on marine birds. In *Ecological Consequences of Artificial Night Lighting.* Edited by Catherine Rich, Travis Longcore. Washington, 94-113

Poot, H., B. J. Ens, H. de Vries, M. A. H. Donners, M. R. Wernand, and J. M. Marquenie. 2008. Green light for nocturnally migrating birds. *Ecology and Society* **13**(2): 47.

Reed J.R., Sincock J.L. & Hailman J.P. (1985) Light attraction in endangered *Procellariiform* birds: reduction by shielding upward radiation. *The Auk*, 102, 377-383

Rodríguez, A., García, D., Rodríguez, B. *et al.* Artificial lights and seabirds: is light pollution a threat for the threatened Balearic petrels? *J. Ornithol* **156,** 893–902 (2015). https://doi.org/10.1007/s10336-015-1232-3

Ronconi, Robert. A., Karel A. Allard, Philip D. Taylor (2015) Bird interactions with offshore oil and gas platforms: Review of impacts and monitoring techniques, *Journal of Environmental Management*, Volume 147, Pages 34-45. https://doi.org/10.1016/j.jenvman.2014.07.031

Welcker, J., Liesenjohann, M., Blew, J., Nehls, G. and Grünkorn, T. (2017), Nocturnal migrants do not incur higher collision risk at wind turbines than diurnally active species. *Ibis,* 159: 366-373. doi:10.1111/ibi.12456

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