Conference on
Wind energy and
Wildlife impacts

Book of Abstracts

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1 Keynote Speakers

1.1 Day 1 - September 6, 2017

Offshore wind: current challenges for sustainable development

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Abstract

Fixed offshore wind farms are becoming more numerous especially around shallow northern European coasts (e.g. UK, Germany and Denmark). However, water depth is a constraint for offshore wind farms deployment since in many other countries (e.g. Japan and USA) the continental shelf drops away suddenly and steeply making the installation of fixed structures much more difficult. Floating offshore wind may represent a major opportunity to transform the potential of this renewable power source, extending the possibility of installing offshore wind farms almost anywhere in the world. Floating wind turbines are proving to be feasible since do not require expensive and difficult-to-install subsea infrastructure and provide the right stability for the turbines to work, reducing platforms drift as well. Two great examples of how far floating wind has come in recent years are Statoil's Hywind Demonstrator project in Norway and Principle Power's WindFloat in Portugal. Although these technological advances are allowing offshore wind installations to go into deeper waters, there is still much that is unknown about the effects on the marine environment. Whilst the number and size of offshore wind developments increases, there is a growing need to consider the population level consequences and cumulative impacts of these activities on marine species and the marine environment, towards the sustainable development of the sector. Main issues related with extending offshore wind to deeper areas are going to be discussed and illustrated, where possible, with experience gained during the WindFloat pilot project installed in Portugal.

Wind Wildlife Fatality:

How we know what we know and how we might mislead ourselves

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Abstract

The main purpose of CWW is to exchange information regarding the impacts of wind power development on wildlife. One concern, among many, is direct fatality caused by collision with rotating blades. Estimating fatality from observed carcasses has been an active topic of research for several years and much has been done to advance the accuracy of the estimates. Nonetheless, this is only a part of the story. Meaningful interpretation of the data and resulting estimates is needed to guide management and societal decisions regarding this form of energy production. I will briefly outline the processes typically used to collect fatality data, then give examples of where misguided interpretation of limited data can lead to inference that is not justified and decisions that might have unintended consequences. I will follow the doom and gloom with a discussion of where we can go from here to improve both data collection and sharing and ultimately, inference regarding fatality impacts from wind.

1.2 Day 2 - September 7, 2017

Mitigating impacts of wind energy facilities on wildlife

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Abstract

Although wind energy is generally recognised as a 'green' renewable energy source with a relatively small footprint, adverse impacts of wind farms on wildlife cannot be neglected. Implementation of the mitigation hierarchy throughout the life cycle of a wind farm ensures that impacts can be mitigated at or below acceptable thresholds. This keynote aims to provide an overview over options for mitigating wildlife impacts, drawing upon research from Norway and elsewhere, and the framework within which these are set for each step of the mitigation hierarchy. The prioritised steps of the mitigation hierarchy are tiered to the consecutive decision gates for wind farm development: (1) avoid when planning, (2) minimise while designing, (3) reduce at construction, (4) compensate during operation, and (5) restore as part of decommissioning. The efficacy of mitigation measures, however, also depends on the sensory, behavioural and aerodynamic capabilities of the species at risk and is highly site-specific. Still, the ecological mechanisms guiding species' responses and potential vulnerability to wind farms can be expected to be fundamental in nature. A more cohesive understanding of the causes, patterns, mechanisms, and consequences of animal movement decisions will thereby facilitate successful mitigation of impacts. This requires adaptive planning approaches that implement the mitigation hierarchy effectively to reduce risks to species of concern. At larger geographical scales, limiting population-level and cumulative impacts of multiple wind farms (and other anthropogenic activity) require still novel approaches such as life-cycle assessments. Although the uptake of the entire mitigation hierarchy throughout the management cycle of a wind farm has been slow to date, its application can contribute towards the goal of lowest possible environmental costs per kilowatt-hour from wind energy.

Compensation:

designing and implementing biodiversity offsets for wind energy projects

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Abstract

With biodiversity being lost at unprecedented rates, mitigating the impacts of development projects is a growing concern, but so is compensating the residual impacts that could not be sufficiently avoided or reduced. International best practice indicates that compensation must be designed and implemented to effectively and fully compensate for the residual loss of biodiversity, by generating measurable conservation gains elsewhere. Full compensation means achieving no net loss (NNL) of biodiversity. In many circumstances, it is financial institutions and company policies that require that greenfield developments in 'natural' and 'critical' habitats for wildlife achieve NNL, or even 'net gain' outcomes.

There are considerable technical and organizational challenges to designing and implementing such compensation, often called 'biodiversity offsets'. Losses and gains must be assessed and compared, to demonstrate NNL, both in-kind and on the basis of targeted loss-gain metrics for impacted species, habitats, etc. These approaches are grounded on the premise that biodiversity losses and gains can be measured and assigned to a particular intervention. The need for verifiable and repeatable methods for quantifying biodiversity losses and gains has become an imperative. These methods carry the risk of oversimplification, as companies will only manage what they can measure. Alternatively, multi-criteria methods aim to embrace complexity. Through examples from wind energy projects and other sectors, we will illustrate the diversity of available approaches, and discuss their respective merits.

Designing and sizing biodiversity offsets is only a first step, and actual implementation often remains an important hurdle. Thus, offset feasibility must also be assessed, to ensure land and expertise can be accessed for the implementation and long-term management, and that offset plans respect the legal and customary rights of local populations. Legal frameworks have been put in place in several countries worldwide to facilitate actual implementation of biodiversity offsets, e.g. by dedicated offset providers and 'habitat bank', and offer the necessary guarantees in terms of financing. The diversity of institutional arrangements for

offset implementation will be illustrated through several examples, including recent changes in the regulatory framework applicable to wind energy in France which culminated in a new biodiversity law voted in 2016. With this, we will discuss opportunities and risks around policy development and implementation.

Biodiversity offsets are focused on the net outcome of projects in terms of conservation. These goals interact with other pressing issues, and in particular the concerns of local communities affected by wind energy development. We will discuss how the ecosystem services concept could be used to analyse these interactions, and enable synergies to be found in the management of biodiversity and social impacts from wind energy.

Finally, we discuss the challenges and opportunities of informing decisions at the corporate level based on data generated at the site or project level. How can such data be compiled, across multiple locations, and made relevant for company management? Also, what does this mean for corporate disclosure on biodiversity?

"Wind Energy, Wildlife Impacts and Banks"

How banks can promote sustainable Wind Energy development

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Abstract

We are facing a vast development of wind energy in developing and emerging countries. This development will be financed to a high extend by development banks like KfW Development Bank. How can financiers assure sustainable implementation and operation of renewable energy projects in countries that do not have robust environmental and social governance, legislation systems and institutional capacity designed to protect their people and the natural environment?

A pioneer in transition:

A horizon scan of emerging issues in sustainable wind energy development

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Abstract

When both the Framework Convention to Combat Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD) have been adopted at the Rio Summit in 1992, certainly no-one anticipated the challenging trade-offs between renewable energy development and conservation of biological diversity. Densely populated and small-sized Germany ranks third in worldwide wind energy capacities, only outpaced by China and US so far. Yet, power and interest transitions, via well-networking civil and political opponents, indicate that efforts to reconcile climate and wildlife protection can no longer be taken for granted.

Funded by the German Federal Environmental Foundation (DBU), the horizon scan aimed at identifying the emerging need for at best collaborative action, based on the viewpoints of various stakeholders and the state of research at the nexus of wildlife conservation and wind energy development. We applied a multi-faceted, inclusive and peer-reviewed research process, building on 50 explorative expert interviews and analysed recent research on this nexus. Interviewees ranged across academia, agencies, consultants, wind developers, associations, and environmental groups. This process yielded a pattern of emerging issues, spanning from *species and nature conservation* concerns, *planning and technology* - focused topics to *societal aspects and participation* issues (Figure 1). Each emerging issue addresses various options for taking action, constituting a catalogue that might contribute either per se or favourably integrated to a relevant programme.

We identified three major trends and clustered the topics: One category encompasses a thorough '*fact-checking*', given the in part tenuous empirical evidence decisions need to be made along. Another set of issues involves the further development of '*model approaches*'. The third major issues rely on conceptual models and empirical data found so far but still lack a '*proof of concept*' and test application, at least in Germany. Involved experts convened in a workshop in April 2017 to discuss the identified topics so far. We launched a supplementary online survey to contribute to prioritise the topics. A final national meeting will take place in

September – with the CWW allowing for discussing the findings beforehand with an international community. Eventually, prioritized 'hot topics' might be considered and launched in a relevant DBU programme.

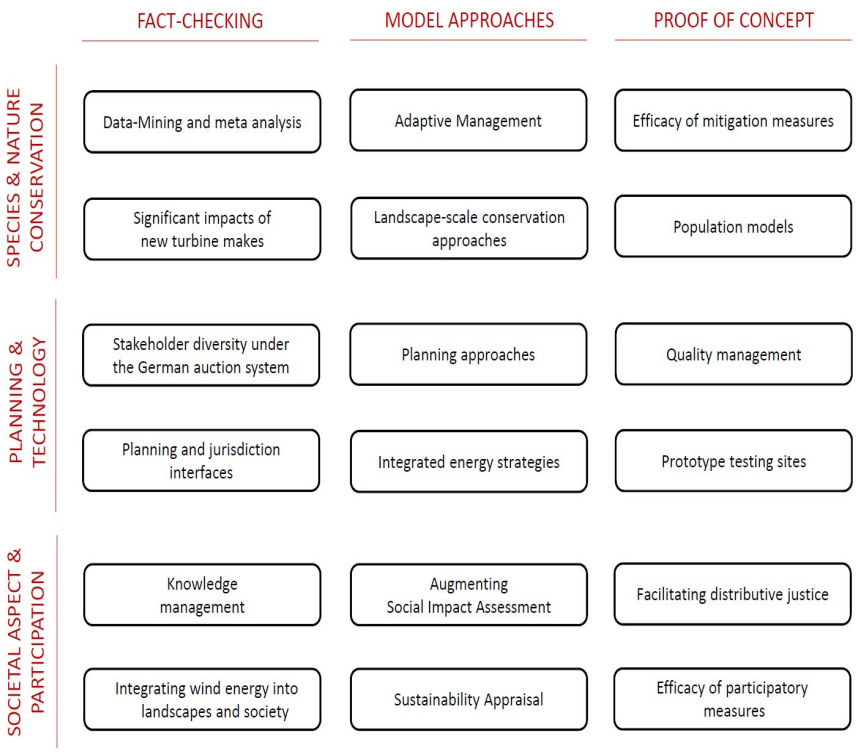

Figure 1: Pattern of emerging issues

2 Oral Presentations

2.1 Day 1 - September 6, 2017

2.1.1 *Parallel Session 1: Species behaviour — Offshore I*

Detection of seabird displacement from offshore windfarms in a highly dynamic enviroment - using simulations for assessing number of surveys required

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Abstract

Although the potential displacement of seabirds from Offshore Wind Farms (OWFs) has been studied for more than a decade, robust evidence of displacement ranges is still sparse, and the issue remains a concern. One of the main reasons for the paucity of empirical evidence for displacement is the limited consistency in how displacement is being analysed. One issue that has been repeatedly discussed is how many surveys are needed for detecting a significant displacement. The highly dynamic offshore environment complicates the assessments with respect to both fieldwork and the analytical work. Many studies have pointed out that taking the dynamic hydrographic conditions into account in the analyses would increase the statistical power (probability of detecting a change). As part of a monitoring program at the Luchterduinen OWF (Eneco) about 23 km off the Dutch coast, we assessed a potential displacement of seabirds using a dynamic multiple regression approach. We included distance to specific windfarms (describing displacement, truncated at 4km) as well as hydrodynamic variables and shipping intensity as predictors of bird densities. Bird densities were collected using standard ship transect surveys during the wintering season. Data from two other OWF projects were also included in the analyses (Offshore Windfarm Egmond aan Zee and Prinses Amalia Windfarm), in total 13 surveys during 2007-2016. To assess the statistical power of the fitted models (for key species; Common Guillemot and Northern Gannet) we simulated new artificial surveys, using the model parameters (excluding distance to windfarm) and actual (modelled) hydrographic conditions during a set of survey dates. We artificially displaced birds

from within the windfarm and also within the windfarm + 4 km buffer. We further refitted the regression models and assessed the number of surveys required for detecting the artificial displacement. For the abundant Common Guillemot 4 post-construction surveys (during the wintering season) were sufficient (power = 1.0) for detecting a 75% displacement of birds within the windfarm, and a 50% artificial displacement resulted in a power of 0.7. When a buffer of 4 km was included the power further increased. For the less common Northern Gannet the power was lower, and high power (> 0.8) based on 4 surveys was only achieved with a 90% artificial displacement from within the windfarm. The power increased with increasing number of surveys also for lower rates of displacement. However, 8 artificial surveys and an artificial displacement of 50% resulted only in a power of about 0.30, indicating that less abundant species require more surveys for detecting a partial displacement, whereas abundant species only require few surveys. Our models will be further updated when new survey data becomes available. The flexible dynamic modelling method we used does not only allow for assessing displacement and power (which are directly useful in management), but also allows spatial predictions in a wider area, based on the relationships to the environmental predictors. Dynamic predictions of the density and distributions of seabirds is a vital first step towards rigorous assessments of displacement impacts.

Large displacement of red-throated divers by offshore wind farms revealed by telemetry and digital aerial surveys

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Abstract

Red-throated Diver (*Gavia stellata*) is a protected migratory waterbird species occurring along the coasts of all countries in Northern Europe during the non-breeding period. Knowledge about diver ecology is highly fragmented. However, the species is considered being one of the most sensitive waterbird species to human disturbances including presence of offshore wind farms.

Our study investigated the potential conflict between Red-throated Divers and offshore wind farms in the German Bight. We analysed, more specifically, the degree of displacement from existing wind farms. The study area supports high numbers of divers during the wintering season and is subject to extensive development of offshore wind energy. We used satellite telemetry to track movements of Red-throated Divers during the annual cycle. In addition, digital aerial surveys were conducted for documenting species distribution and abundance in the German Bight. Telemetry data and survey data were analysed separately using species distribution modelling. We used generalized additive mixed models (GAMMs) for identifying factors describing distribution patterns of the divers. To be able to assess the displacement effect, the distance to windfarms was included as a predictor in the models. The offshore environment is dynamic and constantly changing and we accounted for this by including hydrographic variables and water depth in the models as well as the anthropogenic disturbance.

Both datasets, telemetry and survey data, yielded very similar modelling results. Divers aggregated in the frontal zone created by Elbe river outflow and tidal currents, and showed preference towards shallower depths. Red-throated Divers showed clear avoidance of offshore wind farms as both the probability of presence and predicted densities increased with increasing distance from wind farm perimeters. It remains unknown, however, if displacement of the

mobile species from preferred habitats has direct or indirect impact on individual fitness and population viability.

Responses of marine top predators to an offshore wind farm: a cross-taxon comparison

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Abstract

The number of offshore wind farms is rapidly increasing as they constitute a significant component of global renewable energy strategies. Quantifying the likely impacts of these developments on wildlife is a fundamental part of the impact assessments required in many regions before permission for developments is granted. A key concern is displacement of marine top predators from important habitat during offshore wind farm construction and operation. We present the first cross-taxon evidence for no significant long-term displacement from a UK offshore wind farm for two broadly-distributed species of conservation concern: guillemot (*Uria aalge*) and harbour porpoise (*Phocoena phocoena*). Data were collected during boat-based line transect surveys across a 360 km2 study area that included the Robin Rigg offshore wind farm. Surveys were conducted over ten years across the pre-construction, construction and operational phases of the development. We estimated changes in guillemot and harbour porpoise abundance and distribution in response to offshore wind farm construction and operation using generalised mixed models to test for evidence of displacement. Both guillemot and harbour porpoise were present across the study area throughout all three development phases, providing evidence for no wide-scale displacement during construction and operation. There was a significant reduction in harbour porpoise within the Robin Rigg offshore wind farm during construction, but numbers returned to pre-construction levels during operation. Guillemot abundance remained similar across all development phases. Both guillemot and harbour porpoise showed significant, local changes in density across the survey area that appeared to be independent of the presence of the offshore wind farm and linked to changes in benthic and fish communities. Our results indicate that local prey availability is likely to be more important in determining the abundance and distribution of marine top predators than perturbations associated with offshore wind farm construction and operation.

Assessing disturbance of harbour porpoises during construction of the first seven commercial offshore wind farms in Germany

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Abstract

We conducted a thorough analysis of the disturbance effects of offshore windfarm construction on harbour porpoise using acoustic porpoise monitoring data and sound measurements collected during the construction of the first seven commercial offshore wind farms in the German North Sea between 2010 and 2013. All wind farm foundations were installed using impulse pile driving, and porpoises were deterred from the piling site prior to piling using pingers and seal scarers. At six of these seven wind farms noise mitigation techniques were applied during the majority of piling events, one was constructed without noise mitigation.

Applying GAM analyses and using all available data, we found a clear gradient in the decline of porpoise detections after piling and deterrence depending on the sound level and distance to the piling site. Declines were found to occur at sound levels exceeding 143 dB SEL05 and in up to a maximum distance of 17 km. When only considering piling events with noise mitigation, the maximum effect range declined to 14 km. Porpoise detections declined much stronger during piling events without noise mitigation, however, with declines being still around 50% at distances of 10-15 km, while declines were already only about 25% at 5-10 km distance when noise mitigation was applied. Within the near vicinity of the construction site porpoise detections declined already several hours before the start of piling and were reduced up to about 1-2 days afterwards, while at the maximum effect distance avoidance was only found during the hours of piling.

The application of first generation noise mitigation techniques has thus slightly reduced the effect ranges of pile driving and especially led to a lower decline of porpoise detections over all distances. However, noise mitigation techniques during these six projects were still under development and did not always work equally efficiently. As noise mitigation systems

have been further developed since the construction of the wind farms within this study, a further reduction of disturbance effects is expected during more recent projects.

Analysing daily porpoise detection rates over the entire four year construction period, we found no or even a positive trend in porpoise recordings from 2010 to 2013, so far giving no indications that negative effects occurred at the population level.

From effects to impacts: analysing displacement of Red-throated divers from offshore wind farms in relation to their wintering home ranges

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Abstract

Red-throated Divers (*Gavia stellata*) wintering in the North and Baltic Sea are amongst the most sensitive species to anthropogenic disturbances and known to show strong avoidance of OWFs. As the species is highly mobile, individuals are likely to encounter OWFs frequently during migration and wintering and are thus affected in several staging areas. For the conservation of this red-listed species it is crucial to understand how displacement effects relate to individual movements and winter home ranges.

We tracked Red-throated Divers throughout their annual cycle, using ARGOS satellite transmitters. Birds were captured during winter and spring 2015 and 2016 in the German North Sea and tracked for up to two years. Specifically, we aimed to investigate home range sizes during wintering, the individual overlap of home ranges with existing OWFs and how OWFs affect movement patterns (e.g. relocation distances) in detail. We calculated home range sizes using kernel density estimates for areas with and without OWFs and studied whether an overlap with OWFs leads to changes in usage patterns.

Initial results indicate that home ranges of Red-throated Divers in the German North Sea are generally large and show high individual variability. In some cases, individual home ranges contain several 'hot spots', indicating a patchy habitat use in space and time. Although 95% kernel home ranges frequently overlap with OWF-areas, detailed investigations of individual tracks reveal clear avoidance of OWFs and suggest a change in movement patterns depending on the distance to the closest wind farm. Thus, wintering in the vicinity of OWFs might incur additional fitness costs for these birds. We discuss the implications of these patterns in the context of species conservation and future OWF planning decisions.

2.1.2 *Parallel Session 2: Species behaviour — Onshore I*

A comparison between mountain hawk-eagle's home range of before construction wind energy facility and during construction

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Abstract

There are some problems to wildlife caused by wind energy facilities.

One such problem is alteration of habitat condition . It is thought that alteration to land cover influences habitat conditions of birds, which may cause changes in their behaviors, such as home range and breeding behaviors, especially raptors who are at the top of the ecological pyramid.

Therefore, changes in their behavior possibly influence all ecosystems of the area. Constructing wind energy facilities brings slight changes to land cover, thus it is thought that these facilities change the behavior of raptors.

However, not many case studies show whether the existence of wind energy facilities changes the behavior of raptors. Furthermore, it is few that showing certain assessment method at environmental impact assessment (EIA) of Japan.

Thus, we analyzed the home range of mountain hawk-eagles that live in mountainous regions using trajectories obtained from survey s, and compared the environment (e.g., altitude, pitch, and vegetation) within the home range area before and during the construction of wind energy facilities.

The study area is region has been planned project constructing wind energy facilities in Kyushu (the third largest island of Japan, located in the southwest of the country) region. The observational survey of the wind energy project has been implemented not only from February to August 2013, before construction, but also since January 2015, during construction.

In this study, the survey results for the two periods of before and during construction were used, with two pairs of mountain hawk-eagles (designated A Pair and B Pair) that lived in this area as the survey subjects. These pairs did not engage in breeding behavior before

construction, but they did during construction, with their young also being identified in that period.

Home range was configured as the number of meshes calculated by using the Kernel density method with flight trajectory data. Furthermore, the calculated mesh was corrected using information about distance from the nest.

As a result, the home range size during construction was smaller than that before construction. Furthermore, flight elevation within the home range was lower than before, and a significant difference was found between before and during construction. No significant difference was found between before and during construction regarding constitution of vegetation within the home range. However, comparing the vegetation within the only mesh in which the bird fed, before construction the area was over 50% coniferous, whereas during it was over 50% deciduous , thus a significant difference was found.

It has been reported that the behavior of raptors including mountain hawk-eagles is influenced by the presence or absence of breeding. Because in this study too, each pairs bred their young during construction, it is thought that they changed environment of feeding.

It was shown in this study that even during the construction of a wind turbine, mountain hawk-eagles hold similar composition of vegetation within their home range and engage in breeding behavior.

The surveys have been still ongoing, I will analyze and compare data including after constructing wind energy facilities.

15 years of wolf monitoring plans at wind farm areas in Portugal: what do we know? Where should we go?

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Abstract

Over the last 15 years, more than 900 wind turbines were built within Portuguese wolf range. Due to the endangered status of this large carnivore in Portugal, several monitoring plans were conducted, resulting in a reasonable amount of information on the effects of wind farms on wolves. We reviewed methodological approaches, compiled major findings and summarized mitigation/compensation measures used in Portuguese wind farms.

As standard procedure, monitoring plans relied on BACI analysis of several wolf biological parameters to account for wind farm effect, using various sampling methods such as scats surveys, telemetry, camera-trapping and howling stations. By the end of 2015, wind farms in Portugal overlapped the territories of 22 known wolf packs, with an average of 4.8 wind turbines per 100km2, reaching up to 120 wind turbines inside some pack territories.

Overall results show that effects of wind farms on wolves can be due to habitat disturbance during construction; acoustic and visual disturbance from wind turbines in operation and increasing circulation of vehicles in the road network built for wind-power development. Traffic disturbance was evident during the construction period and first years of operation. The recorded traffic was, in average, 36x higher during construction period than in pre-construction, reducing to 11x higher in the 3rd year of operation.

Wolves showed avoidance to wind farm areas during construction phase and, in some cases, the first years of operation, being that effect limited in time. Regarding breeding patterns, wolf packs already breeding more than 3km away from wind farm areas in pre-construction periods had only minor changes in breeding sites location and reproduction success. However, when wind farms were built closer ($<$3km) to active breeding sites, wolves showed a decrease in breeding success during construction and initial operation phase (only less than 50% of

studied wolf packs were able to reproduce during 1st year of operation phase) and shifts in denning sites that could reach more than 6km away from the windfarms to resume regular reproduction.

These behavioural responses raise conservation concerns since available breeding habitat can be scarce in highly humanized and heterogeneous landscapes, such as Portugal. As a precautionary mitigation measure for future infrastructures, projects should consider a 2km buffer from active breeding sites as 'no-construction' area for all wind farm elements and have traffic-restriction measures to minimize vehicles inside the road network built for wind farms.

No evidence for displacement of wintering Red-breasted geese (*Branta ruficollis*) at wind farms area in northeast Bulgaria: long term monitoring result

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Abstract

While broadly considered 'environmentally friendly' being a clean source of renewable energy, wind farms are not without potentially adverse effects on environmental features, notably birds. The Red-breasted goose *Branta ruficollis* (RBG) conservation status has changed from Endangered in the past to Vulnerable in 2015. The species has changed its winter distribution several times particularly forced by agricultural practices of humans. Its first documented registration is dated c. 2620 BC in a tomb of Nefermaat and Atet in ancient Egypt. At the end of 20th century the species is typically wintering in Kazakhstan. At present, the hinterland of the western Black Sea coast, including Bulgaria, is one of the main wintering grounds of RBG, where flocks co-exist in the same region with circa 200 wind turbines. The Red-breasted geese were first registered in significant number in southern Dobrudzha in 1961 and in the study region in 1964. Since then, this is the primary wintering area for this vulnerable species. This study focuses on RBG because: a) the species is classed as Vulnerable by International Union for Conservation of Nature (IUCN) and as a 'priority species' by several other international conservation instruments; b) the threat to RBG posed by wind farms on their wintering grounds is considered high although this threat is noted as being primarily from collision mortality, and c) availability of information for distribution of RBG in the study area before construction of any wind turbines and current status with circa 200 wind turbines constructed. We hypothesize that the operation of wind parks has caused displacement of wintering geese. We have applied Before-After-Control-Impact approach in the same study area. This simple Before-After study within 20 years includes comparable periods before construction of any wind turbines and when circa 200 wind turbines operates in the study territory, considering 'large scale displacement' from this typical wintering area of

the species. However, according to the results of our study RBG are using the same territory in the same number, but distributed in smaller flocks. Our final results do not indicate displacement of RBG from traditional feeding grounds, but are associated with the changes in the property of land in Bulgaria and the fragmentation of crops including wheat - the main feeding resource for RBG. The present study provides no evidence for displacement effect of wind turbines confirming opportunistic strategy of wintering RBG in the area for the last 20 years. The results are applicable for RBG conservation action plans at national as well as international level. Our results are of primary interest for the planning process in the wind energy development in Bulgaria. The impact assessment in Before-After analyses presented in our study is important part for the adaptive management of wind energy developments in northeast Bulgaria and Dobrudzha region - one of the main target territories for the wind industry.

Wind power plants and reindeer - a synthesis of results from six study areas in Norway

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Abstract

Renewable energy production from wind turbines has received political support in Scandinavia and numerous wind power plants (WPs) have been built and are under construction or planning in semi-domestic reindeer (*Rangifer tarandus tarandus*) ranges. WPs represent potentially negative effects for reindeer behavior and space use. Since 2000, we investigated interactions between WPs and reindeer movement patterns, space use and feeding behavior. Field studies were conducted in six areas, all of which have WPs in operation as of 2015 (Vikna, Fosen, Narvik, Kjllefjord, Vanny, Berlevåg). Field methods applied in collaboration with reindeer herdsmen include experimental manipulations and studies from before, during and after WP constructions, direct behavioural observations of free ranging reindeer, monthly surveys of reindeer populations, counting fecal pellet-group distribution and monitoring movements and space use with reindeer tagged with GPS-collars. We present a synthesis of results and ongoing analyses from these six study areas. Reindeer area use declined along access roads during the construction period in all three areas (Kjllefjord, Vanny and Berlevåg) where this was tested. Reindeer feeding behaviour was unaffected when feeding in close proximity of turbines in all three areas (Vikna, Narvik, Kjllefjord) where this was tested. Overall, reindeer area use was unaffected during the operational period (after construction) in five of the six areas. However, for one area, Berlevåg, preliminary results show significant avoidance, also in the operational period. Reasons for this are under investigation, but presently with data for only one year of the 'after construction/operational' period, it might be a random effect related to temporal variation which needs further investigation. Visibility of the turbines, as well as range properties will be included in further analyses. As of 2017, the Fosen study area will receive 4 new and relatively large WPs soon to be in construction and planned to be completed in 2020. Here, we have over 6 years of "before" data to be tested with the construction period and operational period in the years to come.

Wind turbines cause functional habitat loss in migratory soaring birds: results from a gps tracking study with black kites

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Abstract

Many wind-power plants are operating or being constructed in critical areas of migratory soaring bird flyways, including bottlenecks of obligatory passage. It is known that such projects can cause important mortality on these birds, but we still have a poor understanding on how the increasing number of wind turbines in such sensitive areas, may impact habitat availability and use. In this study we aimed to identify and quantify the displacement effect of wind turbines on a migratory soaring bird species at a critical bottleneck.In particular, we tested if the area used by soaring birds is reduced due to avoidance of wind turbines.

Soaring birds' movements during the post-breeding migration of 2012 and 2013 were studied in the Strait of Gibraltar, in an area with a high number of wind turbines (n=160). We collected data from 130 Black kites (*Milvus migrans*) tagged with GPS-GSM tracking devices (1-minute temporal resolution) resulting in 77,000 GPS fixes. Using Dynamic Brownian Bridge movement models we estimated the Utilization Distribution (UD) of the sampled bird

population. The influence of wind turbines, orographic and thermal uplift (modelled by the INTACT Micrositing GIS tool) on space use was then modelled.

Our results showed that wind-power plants cause functional habitat loss for flying birds. Birds avoided moving through areas closer than 880m of wind turbines and this avoidance increased with the proximity to these structures. Also, both orographic and thermal uplift velocities had a positive effect on bird UDs.

We stress the need for new regulations for wind-power production to recognize the aerial habitat loss caused by wind turbines and not only the possible collision risk of soaring birds. Additionally, potential up-draft areas for soaring birds should be carefully analyzed when planning new wind energy facilities, or when repowering existing ones, to avoid conflicting areas.

2.1.3 *Parallel Session 3: Fatality assessment*

Collision fatalities amongst birds at offshore wind farms: why real field monitoring should validate models

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Abstract

Until recently, detecting bird collisions at offshore wind farms was virtually impossible. Discussions on the importance of doing so were therefore theoretical and easily put aside in favour of models or guesstimates. In the framework of a new multi-year research programme on ecological effects of offshore wind farms in The Netherlands ('*Wozep*'), a review was carried out on '*methods and techniques for field validation of collision rates and avoidance amongst birds and bats at offshore wind turbines*'. This review shows there are now different systems available capable of automated detection of bird collisions at offshore wind farms. These will be presented and shortly evaluated. The overall conclusion is that '*impossible*' has changed to '*has been and can be done*'.

After that, the presentation will focus on the need of field measurements of collision fatalities and field validation of Collision Risk Models. We will argue why all stakeholders will benefit from doing these field measurements as soon as possible.

In the current practice, CRMs are used in the EIA process, and other assessments, before permits or concessions are obtained. The results of CRM calculations are generally strongly dependent on estimates for only a few parameters, and the outcomes may vary widely with minor changes in just a few of the input estimates. Examples will be given. Field validation of these parameters, e.g. avoidance of the wind farm and/or the turbines within the wind farm, turns out to be difficult: the measurements can be done, but a field value of avoidance with an accuracy of two decimals is problematic.

Field measurements of the actual number of collisions, will yield results that can be used to validate the models in a different way than so far has been done: validating results rather than

the (very sensitive) input parameters. If we know the order of magnitude of the number of bird collisions at a site, together with flux, altitude distribution, species composition, avoidance behaviour and other relevant information, the models can be interpreted and used much better. Confidence intervals will likely be smaller, which is essential for the ex-ante evaluation of especially larger offshore wind farms or cumulative effects for many wind farms, e.g. the current Dutch situation to have installed 4.500 MW by 2023 and further ambition of 11.500 MW by 2030.

We will argue why investors and regulators need these field measurements as soon as possible. On the one hand, using precautionary estimates for parameters, effects may now be over-estimated. This can lead to:

1. not permitting wind farms that in reality would have a lower mortality than predicted now, using precautionary estimates, or

2. taking costly mitigation measures to reduces the impacts.

On the other hand, due to the uncertainty in input parameters and the sometimes large effects of minor changes in values, effects may be under-estimated which may lead to effects on bird populations that are not acceptable in the framework of e.g. the EU Birds and Habitat Directives.

Using detection dogs in bat and bird carcass searches in a South Africa's wind farms context: benefits and constraints

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Abstract

With the continuous growth of wind energy demand and production, the need to have solutions that allows to understand its real impact on ecological values gains is of great importance. In South Africa, as in many other countries, the assessment and monitoring the impacts of operating wind farms is a requirement from the local best practice guidelines. Accurate and efficient methods are important to determine wildlife fatalities resulting from operating wind turbines. Currently, bat and bird fatalities in South Africa are accessed during field surveys carried out by human observers, normally with low accuracy and efficiency. Efficiency and Accuracy are applied in the context of this work in terms of: less time and effort required to find carcasses; and more carcasses found/detected, respectively.

Detection dogs can be a tool that will increase the carcass detection probability on carcass searches around operating wind turbines. Detection dogs have been used across the world in a variety of ecological studies such as scat or carcass detection.

We evaluated the accuracy and efficiency of human and dog teams in real world conditions at a wind farm in South Africa to see if dogs are a valid alternative to humans. South Africa wind farms may pose additional difficulties to using sniffing dogs searching for bat and bird carcasses. Most wind farms in South Africa are located in remote areas which may require special arrangements to have dog-handler teams conducting the continuous searches around wind turbines. South Africa environmental conditions may also pose additional challenges to the use of detection dogs, especially in areas that experience extreme weather, such as very hot and dry conditions.

Bioinsight, in collaboration with the Eskom/Endangered Wildlife Trust strategic partnership South Africa, set up an experimental design at a wind farm in the north of Western Cape

in South Africa during the hottest season to evaluate the performance of sniffing-dogs detecting bat and bird carcasses and how its efficiency compared with the local human searchers. The influence of several environmental and field variables such as vegetation type, wind speed, air temperature, visibility or day (learning) in the accuracy and efficiency of detection dogs and humans was investigated.

The results show that sniffing dogs are more accurate and efficient than humans and are not influenced by any of the environmental variables tested in both metrics. Human accuracy is influenced by the vegetation and type of carcass, and have at least less 20% probability of detecting carcasses than sniffing dogs.

The results demonstrated that detection dogs can be a useful tool when searching for bat and bird carcasses South African wind farms and can also reduce known bias in fatality estimation when compared to human searchers. The challenges of using sniffing dogs searching for bat and bird carcasses in remote areas with extreme environmental conditions will also be explored. The increased accuracy and efficiency of detection comes at a higher cost than employing human searchers and in areas favoring higher human detection rates it is recommended that the use of human searchers should be considered before dogs are deployed. If project specific terrain results in a lower average detection by human searchers than the results obtained in this study, the use of detection dogs should be considered if warranted by environmental factors and species of concern.

Camera-trapping as a methodology in the assessment of carcass persistence, used in bird and bat fatality estimates at wind farms

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Abstract

In the last two decades, there has been a worldwide increase in renewable energies, specifically wind energy. Despite its advantages, wind farms usually carry negative impacts, mainly on birds and bats populations. One of these impacts is direct mortality or injury due to collision with wind turbines. To assess this impact caused by wind farms presence, carcass searches near turbines are mandatory, as well as the two most commonly used estimators, so to adjust mortality estimates: rates of searcher detection and scavenger removal of carcasses. The latter considers the possibility of carcass removal by scavenging animals or decomposition between monitoring sessions, and aims to estimate the average number of days a carcass persists before it is removed by scavengers and decomposition, which influences the number of carcasses detected.

Carcass persistence rate trials methodology consists in randomly placing samples of carcasses under the turbines, which are then checked under a pre-defined inspection protocol. The protocol that has been more used in Portugal consists in daily checks by a field technician, during a 15-day period. To avoid this effort and to reduce costs, camera traps are starting to being looked at as an alternative, while also allowing the collection of the exact removal time and the characterization of the scavenger's guild, which might lead to further conclusions regarding the removal rate estimation.

In this work, we compared the effectiveness of camera-trapping technology in comparison to the conventional method used in carcass removal trials, addressing both methods advantages and handicaps. We conducted trials in five different wind farms, in a total of 8 campaigns, across different seasons. We distributed 30 carcasses, with three different size classes, in each of the trials, and monitored each of them with digital infrared cameras. A visit took place 7 days later to maintenance purposes and to identify camera malfunctions, and 7 days after that to collect the cameras.

Camera traps allowed to record the exact removal time for most of the carcasses, and allowed the reduction of the field work from 15 to 5 days, with the cost saving associated. Also, with daily visits to the carcasses locations, the technicians' odor might be more present and influence the overall results, while only three visits take place when using camera traps, instead of the fifteen in the conventional method.

There were some cases where it was not possible to record the exact removal time and a few other cases where the minimum known period of removal increased. In both cases, it was due to camera malfunction or poor camera placement by the technicians. We present guidelines to be taken in consideration when using this method. There were also a few cases where all data was lost due to camera theft.

We have analyzed the data collected from camera trapping trials to evaluate the influence of continuous vs. censored data on estimation and the influence of insufficient data from some of the cameras on the estimation, and have not found significant differences.

Camera-trapping demonstrated to be a good method to replace the conventional one, ensuring the same or best results, while adding extra value regarding the characterization of the scavenger's guild, and allowing a significant cost reduction due the decrease in the number of visits to study area. There is an initial investment requirement, though, which must be taken into consideration.

The use of detection distance of fatalities for the estimation of searcher efficiency and implications for calculations of fatality rates

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Abstract

Searcher efficiency is usually assessed by means of putting carcasses over a wind farm followed by a carcass search by the potential observers that will work on site. Here we present a novel methodology that uses the distance at which 124 carcasses were detected by observers to evaluate the searcher bias. Carcasses were divided in four groups according to size, ranging from small (passerine), medium (pigeon-small falcon size), large (raptor other than vultures and falcons) and very large (vultures). Visibility of the fatality was also classified from 1(bad) to 3(good). Size and visibility were uses as covariates that may affect detection distance. Fatalities were found at a distance that ranged from zero to 45 meters regardless their sizes. We applied canonical semi-normal and hazard-rate distributions the distances using a cosine term for a better approach. The best model it was the Hazard-rate key function with cosine adjustment term of order 2 (AIC=500.42) and Distance sampling Cramer-von Mises test =0.30 (unweighted). Both carcass size and visibility had nearly significant effect in detection distances (0.06 and 0.07 respectively). We obtained the detectability curves following the common procedures in the DISTANCE (Buckland et al. 2001, 2004). We estimate the detectability values using R software with the packages "Distance" (Miller 2015a) y "mrds" (Miller 2015b), grouping small and medium sizes together and also large with very large ones. The average efficient detection distances were respectively 2.95 and 18.26 meters; whilst the probabilities of detection 0.11 and 0.45. Again the Hazard-rate key function with cosine adjustment term of order 2 had the best adjustment models. The goodness of fit for both models was good Distance sampling Cramer-von Mises test (unweighted) > 0.05 in both cases.

Despite these preliminary results, the use of the detectability distances helps to avoid the use of searcher efficiency trials. There is no need to put carcasses or decoys such as chickens or quails to be found by observers. The use of real fatalities provides with mathematical robustness in the analysis and representativeness situation at which fatalities spread over

the study area. It also decreases the costs and potential problems when dealing with non-native carcasses from out of the site. On the other side and after the review of 38 post cons monitoring reports in the study area, it has important implications as the environmental consents established a minimum 20 minutes search / turbine with all turbines being searched on each visit. Observers missed carcasses they never detect with no corrections provided. Public bodies should amend the environmetal consents to improve the results and measure impacts properly.

Comparison of area correction methods for post-construction fatality monitoring studies

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Abstract

Post construction fatality monitoring studies at wind facilities sometimes include plots that are incompletely searched. Plots may be incompletely searched for logistical reasons (e.g. rugged terrain) or as a cost-saving measure (e.g. searches confined to graveled road and turbine pad areas). Statistical methods to adjust fatality estimates to account for unsearched areas are available but few methods have been published and practical limitations are not fully known.

We discuss the motivation, pros, and cons associated with the polynomial logistic regression method to adjust fatality estimates and present a second set of methods which uses maximum likelihood estimation of density models for carcass distributions to adjust fatality estimates for unsearched areas. We discuss the practical limits of the methods that are presented, including minimum numbers of carcasses needed and minimum searched area needed to obtain reliable estimates.

Preliminary results suggest that model-based methods can provide reliable area correction factors but each has its limitations and the best choice may be context-specific. Incompletely searched plots are a common feature of post-construction monitoring studies. They are in some cases unavoidable, and in many cases have been deemed acceptable by regulatory agencies. The results presented here provide important guidance on methods to obtain accurate fatality estimates when plots are incompletely searched.

2.1.4 *Parallel Session 4: Species behaviour — Offshore II*

Strategic post consent monitoring of breeding harbour seals at the Wash SAC

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Abstract

In the recent years there has been a move away from site specific monitoring of marine mammals at offshore wind farms in the UK and a move towards more strategic monitoring. The Dudgeon Offshore Wind Farm (DOWF) Marine Licence included a requirement to monitor the potential disturbance to harbour seals during the construction phase as a result of pile driving noise. Disturbance to harbour seals could result in reductions in foraging success, loss of condition and reduced fecundity, however these impacts would not be detected by traditional post consent monitoring methods. This led to an opportunity for DOWL to contribute to wider efforts to understand the status of the Wash harbour seal population.

The DOWF lies off The Wash which supports an important harbour seal population and is a designated Special Area of Conservation (SAC) for harbour seals. Annual aerial surveys provide estimates of numbers of seals hauled out during the moult. This provides a consistent index of population size, but it is a relatively insensitive index of current population status.

Estimates of pup production are needed to assess short term changes in status. Therefore a strategic monitoring approach was adopted to intensify monitoring of the SAC harbour seal population during the breeding season to provide robust estimates of pup production. Concentrating surveys over the construction period provided a short term index of status coincident with potential disturbances. Surveys also provided estimates of peak pupping dates and breeding distribution. Ten aerial surveys were undertaken during the 2015 and 2016 breeding seasons. Peak pup count dates were similar to previous surveys in 2008 and 2010, confirming that single breeding survey counts in previous years (2002 -2014) were close to the peak pup count and therefore directly comparable. The maximum pup count from 2015 was 25% lower than the 2014 count, but the 2016 peak count was 17% higher than the 2015 count. In isolation that result would suggest that the pile driving activity at DOWL in 2016 had no detectable negative impact on pup production. When included in the time series of

pup counts, these apparently wide fluctuations have little impact on the fitted pup count trend which shows a 7.5% p.a increase since 2001. An index of productivity created by dividing peak pup counts (indices of pup production) by the peak moult counts (indices of overall population size) suggests that apparent population fecundity has increased dramatically since 2001. An increasing proportion of the seals breeding in the Wash are now going elsewhere to moult. It is not clear if this represents an influx of breeding females or an increasing tendency to leave the Wash during the moult.

The 17% increase in 2016 is unlikely to indicate beneficial effects of piling, so the wide fluctuations in pup counts are probably unrelated to windfarm activity. The fact that the coincidental change was positive means that results can be safely disregarded in terms of disturbance effects. These results highlight the importance of setting monitoring programmes in context of wider and longer term data sets.

Filling up the gaps: addressing knowledge gaps on ecological impacts of offshore wind farms in the Netherlands

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Abstract

High ambitions for offshore wind energy development have led to the need for appropriate environmental impact assessments, including the assessment of the cumulative impact of successive series of offshore wind farms (OWFs) to become installed and operational, in addition to other potentially damaging human activities. In a preceding project the Dutch government has developed a framework (called 'KEC' in Dutch) to deal in a more systematic way with this issue of cumulative impacts. The development of this framework as well as its actual application have been reported upon in the previous edition of CWW. Apart from offering a tool to cope with cumulative effects of multiple wind farms successively becoming operational, this 'KEC' has also clearly shown that despite extensive fieldwork and modelling, fundamental ecological knowledge gaps still persist. Due to these knowledge gaps and the following uncertainty, the Dutch government has prescribed some strict, and potentially costly, mitigation measures to comply with the precautionary principle.

In 2016 an integrated ecological research programme has been set up by the Dutch government for the period 2017-2021. This programme aims at decreasing the scientific uncertainties and reducing the costs of mitigation. Additionally it will, look for ways to render OWF development more compatible with ecological conservation.by a more careful incorporation into marine spatial planning. The programme has a broad scope, ranging from seabirds and marine mammals in relation to possible shifts in habitat use, habitat quality and/or carrying capacity linked to installing or operating OWFs, to migratory bats and 'land' birds and whether they are attracted to OWFs and to what extent they become exposed to fatality risks by collisions. The programme thus consists of several work packages that include a wide range of activities, such as the improvement of predictive models for disturbance of seabirds and marine mammals and its consequences for individual fitness and population trends, calibration of these models by field measurements, attempting to identify and quantify the relevant shifts in habitat use

and habitat quality due to the presence of operational OWFs, the degree to which fluxes of roaming or migrating birds and bats actually enter (or avoid) OWFs and, within an OWF, enter or avoid the rotor swept area. Attention will also be given to possible changes in the hard and soft substrate benthic communities in and around OWFs, as well as the fish fauna because of their complex role for the higher trophic levels.

At this moment the first research results from the different work packages are coming in so we will be able to present these and more in September.

Displacement effects of offshore wind farms on Red-throated divers (*Gavia stellata*) relative to the effects of other human activities

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Abstract

Separating natural fluctuations in avian distribution and abundance from changes caused by human activities is a key challenge in environmental impact assessments (EIA). Displacement effects may preferably be analysed using model-based approaches that include physical habitat features since count data are spatially limited and do not allow a complete characterization of an area. Here, we present the successful application of a spatial model to assess distributions of Red-throated divers (*Gavia stellata*) in relation to the construction and operation of offshore windfarms in the Outer Thames Estuary. This area contains several offshore windfarm sites that have been developed over the last fifteen years. The area also supports the largest aggregation of wintering red-throated divers in the UK. Spatial models were based on bird count data from aerial high-resolution digital images collected since 2009 in the Outer Thames Estuary. Pre- and post-construction survey data were analysed using the Complex Region Spatial Smoother (CReSS) and the Spatially Adaptive Local Smoothing Algorithm (SALSA). Models were developed using all available data from the pre-construction, during-construction and post-construction periods for the London Array offshore wind farm. CReSS models included both static (e.g. distance to shore) and variable (e.g. sea surface temperature) environmental factors to categorise and determine a relationship between the environment and bird abundance. The model allowed extrapolations from the surveyed area to the rest of the area of interest using a prediction grid. The model building, selection and testing followed the latest guidance for CReSS/SALSA using the MRSea package in R. Divers showed a significant decline in density between the pre-construction and during-construction periods. Diver distributions altered with proportionally fewer birds being seen in the wind farm and surrounding areas during the construction period than were recorded during the pre-construction period. First results from the post-construction period suggest that divers may recolonize the wind farm after construction has ceased. The CReSS/SALSA method provides a suitable model framework on which to base further analysis of displacement effects

of offshore windfarms on avian distribution and abundance relative the effects of other human activities (e.g. boat traffic). Incorporating additional post-construction data will allow more definite conclusions on the net effect of offshore wind farms on birds. EIA of offshore projects should incorporate spatial models based on existing census data to test the significance of changes in avian distribution and abundance over time and to define the scale and source of potential impact objectively.

Evidence based tools to assess and mitigate population level impacts of wind farm developments - the case of the DEPONS project

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Abstract

Human caused climate change is real, having very tangible effects already, and at the current trajectory constitutes a major threat to human societies and to biodiversity as we know it. The faster we can make the transition to renewable energy the more we will be able to limit global warming and the associated potentially very dramatic consequences. Time is of the essence, and therefore costs matters as well. The more cost effective we can build out wind power and other renewable energy sources, the faster we can make that transition happen, and the less we and the coming generations will suffer.

The development of wind power will inevitably have negative effects on the local environment. That goes for all energy sources. Whilst the geographic scale of such effects are relatively small, compared to the emissions mediated effects of fossil based energy sources, cumulatively over a large number of developments these effects might reach a level where populations of sensitive species could be impacted.

How do we know when we should start being concerned about specific effects of individual and multiple wind farm developments? How do we know when mitigation measures are really called for? How do we ensure well considered wind farm planning decisions balancing the needs for a rapid transition to renewable energy sources and securing the long term viability of the directly affected species and populations?

The obvious answer is, we need knowledge! Not only knowledge about the effects of wind farms, which, and for good reason, has been in focus for a long time, but more importantly we need knowledge and means to be able to convert the observed effects into consequences for the affected populations. Something that requires dedicated strategic research and a good basic understanding of the relevant species and populations, as well as models that can reliably make the link between the effects and the impacts.

An insurmountable and unrealistic aspiration? We think not. We think it is a necessary one. Both wind farm development and species conservation are far too important not to have a solid knowledge base for planning decisions with potentially significant implications for both.

We set out to do exactly this for the case of wind farm piling noise disturbance effects on the harbour porpoise population in the North Sea. We being a group of major European offshore wind developers, acknowledging 4-5 years back that this was not going to happen within, for us, an useful timescale (if at all), if we didn't take action.

The result is the Disturbance Effects on the Harbour Porpoise Population in the North Sea (DEPONS) project (http://depons.au.dk/). An ambitious project, involving extensive and challenging field work to build the evidence base to inform an Individual Based Model simulating behaviour and noise responses of individual porpoises allowing assessment of population level consequences of cumulative wind farm development scenarios. The presentation will describe how the project was established; its content and deliverables; and how we strive for independence, high quality and applied value of the outcome. Examples will be given of the actual work conducted and first results will be presented, including the first publicly available and ready for use version of the DEPONS model.

Cumulative habitat loss for sensitive seabirds resulting from offshore wind energy and shipping traffic and implications for Marine Spatial Planning

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Abstract

For seabird species sensitive to disturbance, such as loons (divers), auks or sea ducks, habitat loss through displacement from resting and feeding areas is considered a primary threat in the German North Sea. Although anthropogenic uses with a high disturbance potential like offshore wind farms (OWFs) and shipping traffic not only demand an increasingly large area in the German North Sea but are also interacting with each other, these uses have been mainly assessed individually and in isolation in current environmental impact assessments. As part of an ecosystem-based management, Marine Spatial Planning facilitates cross-sectoral planning and can potentially consider marine conservation needs more appropriately. For this, approaches to the calculation of cumulative environmental impacts of several sectors are required, but are still scarce.

In this study we focus on the estimation of cumulative effects of OWFs and shipping traffic on the distribution of seabird species sensitive to disturbance. In particular, we aim to quantify the cumulative habitat loss caused by the two utilization forms in different development scenarios. The species group of loons (Red-throated diver *Gavia stellata* and Black-throated diver *Gavia arctica*) was selected as examined species, as they are shown to have a very high sensitivity to disturbances and are treated as priority species in authorization procedures for wind turbines at sea in Germany.

While numerous studies on the effects of OWFs consistently document large-scale avoidance of the affected areas by loons and other sensitive seabird species, the effect of shipping on seabirds has still been relatively little explored. Previous studies and observations have shown that loons flush far in front of approaching vessels and avoid heavily used shipping routes. However, to our knowledge, the large-scale effect of maritime traffic on the distribution of seabirds has not yet been studied.

Hence, we (1) model the effect of ship traffic on the distribution of loons using large-scale navigation data of ships and general additive modelling; (2) calculate the cumulative habitat

loss caused by OWFs and ship traffic under different development scenarios in the German Bight; and (3) propose possible stress limits with regard to population effects and adaptability.

Our results show that the suitable habitat of loons in the German Bight is already heavily impacted by disturbances caused by OWFs and maritime traffic. If all wind farm plans are implemented, a large proportion of the suitable habitat will be affected jointly by both types of use leading to a considerable loss of loons resting in the German Bight with presumably negative effects on population level. For Marine Spatial Planning, this means that no further areas for wind energy generation should be identified in the suitable loon habitat. We show that the relationship between the frequency of ship traffic and the distribution of loons is highly significant. Therefore, intensified ship traffic and possibly changing shipping lanes along with the construction and maintenance of OWFs have to be taken into account by modelling prospected ship traffic in the context of impact assessments for OWF approval.

2.1.5 *Parallel Session 5: Species behaviour — Onshore II*

The Iberian wolf and wind farm environmental impact assessment in Portugal - a review

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Abstract

In Portugal, wind energy production took its first steps in the mid-nineties. Over the following two decades, an increasingly high number of wind farms were installed throughout mainland Portugal, mostly in mountain areas of the northern and central regions of the country. Some of these areas overlap with Natura 2000 sites or have important biodiversity values included in the Birds and Habitats Directives annexes. Several of those wind farms, due to their dimension and/or location, required an environmental impact assessment (EIA). Terrestrial mammals are not an animal group usually considered in wind farm EIA. However, the Iberian wolf in Portugal is protected by National and EU laws, and is also an emblematic species of the Portuguese conservation policy. Since the first EIA of wind farms located in wolf territory, some measures (mitigation measures and monitoring plans) regarding this species had to be implemented in concordance with Environmental authorities decisions. Considering the significant number of wolf measures that were determined and their relevance for the EIA and development of wind farm projects, we have compiled and analysed the evolution of those measures, regarding their complexity, practicability and applicability,by reviewing all of the Environmental Impact Declarations of wind farms located in the wolf's range and several of the respective post assessment process documents.

We have divided the wolf measures into three groups: 1) monitoring plans, 2) minimization measures and 3) compensation measures, and within each group, we stratified accordingly to the stage or stages of the wind farm project that they should be applied to: project, construction and/or operation. We also analysed the alterations of the measures throughout the three EIA stages: Environmental Impact Declaration, construction project and post assessment process.

1) Monitoring plans were established for almost every wind farm analysed, beginning at project stage up to operation stage. Although there were differences between plans (e.g. sampling area size, sampling frequencies), the methodologies were very similar. Notably, some wind farms joined efforts and developed regional monitoring plans with unified methodologies. 2) As expected, most of the established minimization measures were for the construction stage, most of them regarding the construction schedule. In some cases, in the project stage, limited or no construction sites were established in order to safeguard the most sensitive areas.

3) The majority of the wind farms also had to implement compensation measures. These were diverse and most of the times non-specific. In some regions, several wind farms with this obligation created an association that enabled the participation of many of them., and through this association, under the supervision of the National Nature conservation authorities, many habitat management projects have been developed.

Although this is a national analysis of a specific species, it can give us an overview of the amount and diversity of measures established in wind farms EIA, for a single species. We think that it can be a tool to help optimize the EIA proceedings for wind farms in wolf areas. This study also shows the importance that the Iberian wolf has on conservation and biodiversity policy in Portugal by the number of measures implemented by wind farms regarding this species.

Inter- and intra-specific variation in avoidance behaviour at different scales in migratory soaring birds

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Abstract

Wind farms may cause adverse effects on birds, including loss of habitat, disturbance, and especially mortality resulting from collisions with turbines. Although recorded casualties differ widely between wind farms, several studies have shown that soaring birds such as raptors are particularly vulnerable to collisions. Birds may undertake behavioural responses towards the presence of wind farms or individual turbines generally designated as avoidance. The scale at which such responses are undertaken determines whether it is macro-, meso- or micro-avoidance.

With the aim of evaluating the prevalence of different types of avoidance behavior among migratory soaring birds we compared the results from monitoring programs conducted at wind farms that markedly differ in size, layout and location: the Barão S. João Wind Farm (BSJWF), Southwest Portugal, comprising 25 two-Megawatt turbines whose blade's swept area covers from 35 m to 125 m above ground level; and the much larger Gabel el Zayt Wind Farm (GEZWF), by the western coast of the Red Sea in Egypt, containing 100 two-Megawatt turbines whose swept area ranges from 20 m to 100 m high. 4-7 vantage points were used in each case to monitor the whole autumn migration period (15 August - 30 November; since 2009) in the BJSWF or the main spring migratory period (20 February - 20 May; since 2016) in the GEZWF. Monitoring involves drawing accurately the trajectories of all soaring birds flying inside or towards the wind farm as well as recording variations in flight height or flight behavior. In both wind farms a radar and visual-assisted temporary turbine shutdown on demand is operated in order to reduce collision mortality.

Altogether we detected almost all species of migratory soaring birds occurring in the Western Palearctic in the two monitoring schemes. Griffon Vulture *Gyps fulvus*, Short-toed Eagle *Circaetus gallicus*, Common Buzzard *Buteo buteo* and Black Kite *Milvus migrans* were the most abundant species in the BSJWF, where nearly 5,000 soaring birds occur yearly. White Stork *Ciconia ciconia*, Steppe Buzzard *Buteo b. vulpinus*, European Honey Buzzard *Pernis*

apivorus, Great White Pelican *Pelecanus onocrotalus* and Levant Sparrowhawk *Accipiter brevipes* were the most abundant species in the GEZWF area, where almost 400,000 soaring birds were counted.

To assess the occurrence of avoidance at different scales we analysed data on the spatial distribution of movements around and within the wind farms, on the minimum distances of flying birds to operating and idle turbines and on changes in trajectory, flight height and flight behaviour before and after crossing turbine rows.

Preliminary results indicate that avoidance behaviour regarding crossing trajectories is species-specific and that larger species showing lower manoeuvrability are often less prone to adopt avoidance behaviour therefore incurring at higher collision risk. On the other hand most of the species adopted meso-avoidance regarding flight height, gaining height when flying over the wind farms. Inter or intra-specific differences in gregariousness and the layout of the wind farms also seemed to affect avoidance behaviour. We discuss that factors affecting avoidance at different scales should be taken into account when evaluating potential impacts of the implantation of a projected wind farm or when designing site-specific mitigation measures for wind farms already constructed.

Wind farm effects on migration flight of swans and foraging distribution at their stopover site

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Abstract

Effects of windfarm on birds have appeared as bird strike, habitat loss, barrier effects and so on. In Japan, windfarm construction has now been promoted under environmental impact assessment (EIA) as required by Japanese law. However, the windfarm impacts have not been enough assessed since we had never have a chance to be able to compare behavior and distribution of birds before and after the construction and/or operation. Here we investigated macro avoidance and foraging distribution of swans near windfarm before and after operation of windmills in Tohoku region of Japan.

Migratory flight trajectories were surveyed by three fixed-point observation near a newly constructed windfarm in spring and autumn of migratory season of swans. The number and the shape of the trajectories were compared among before construction, before operation, and after operation of windmills. Macro avoidance to windmill was defined with both the turning radius and the trajectory altitude of swans. Foraging distribution of swans in farmland was also surveyed by car census around the windfarm.

After constructing windmills, swans avoided the windfarm area before approaching windmills. Thereby migratory swan flight population was drastically decreased in the area, while foraging distribution of swans around windfarm had no effected by the operation.

Since swans avoided windmills beforehand, their collision risk could be quite a low. However, their migratory flight trajectories revealed that swans had to go around a windfarm area. The additive energetic cost for extra flights and the cumulative effects for avoidance should be investigated in the future. Our study, further, showed that the foraging distribution of swans was not interfered by windmill operation. It might be because the location of windfarm held enough distances with the foraging fields in this case. As the next step, an effect when windfarm was located near their foraging habitat should be evaluated.

Where eagles dare: understanding collision risks, behavioural patterns and population impacts of white-tailed eagles at Smøla Windfarm, Norway

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Abstract

At a 68-turbine wind-power plant at Smøla, coastal mid-Norway, white-tailed eagles (*Haliaeetus albicilla*) (WTE) are frequently killed by wind turbines. Using GPS satellite telemetry, recorded collisions and vantage point observations, we have studied movement patterns and collision risk of the eagles. Vantage point observations revealed that there was no change in the flight behavior within the wind-power plant compared to outside. GPS satellite tagging showed that 25% of the WTE flights at Smøla were within the height of the rotor-swept zone of the turbines. Weekly searches with trained dogs were conducted to find bird carcasses, and 75 white-tailed eagle collision victims were found during the study period 2006-2016. Molted feathers from adults and feathers from nestlings of WTE were subjected to DNA analysis, enabling us to track the origins of and relationships between collision victims, and to produce a matrix population model. The most influential demographic parameter in the population model was adult survival. The distance from the nest to the power-plant was important; breeding close increased the mortality risk and reduced productivity. We found that molted feathers of many WTEs could not be classified as breeders, indicating the presence of a relatively large proportion of floaters on the island, which could be able to replace the collision victims. Frequent use of night roosts in spruce plantations close to the wind-power plant seems to pose an additional risk. Compared to pre-construction data, there was displacement of breeding pairs from the power-plant area.

We have shown that turbine-induced mortality can affect the population dynamics of a large raptor in its breeding area, and that such species are vulnerable to collisions with turbine towers when such installations are placed in their breeding habitat. Therefore, as post-construction mitigation efforts may prove to be difficult, efforts should be focused at best placement, involving selection of habitats of little use by soaring or breeding raptors.

Also, the knowledge of eagle behavior obtained from our research may prove important during repowering or re-siting of power-plants in habitats of similar types.

2.1.6 *Parallel Session 6: Species fatality and vulnerability*

Estimating the potential mortality of griffon vultures (*Gyps fulvus*) due to wind energy development on the island of Crete (Greece)

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Abstract

Crete has been characterized as an area with a high wind-energy capacity due to its mountainous and rugged terrain and the strong winds that prevail there almost throughout the year. In the same time the island constitutes the last stronghold for vulture species in Greece, currently holding the largest insular population of Eurasian griffons (*Gyps fulvus*) worldwide (i.e. 350 reproductive pairs or an estimated number of ca. 1000 individuals). Given the empirical data on the mortality of large raptors due to collision with wind-turbine blades, the aim of the present study was to predict the potential impact of wind-energy installations on the Griffon vulture population on the island. The study was developed into two steps namely: (a) the spatial mapping of the existing and planned wind-energy projects up to the year 2012 (i.e. 2.300 MW) and the delineation of their risk area, and (b) the calculation of the annual collision rate based on the expected number of vulture risk flights and the probability of being killed. Overall, the minimum number of fatalities due to collision of vultures to wind-turbine blades was estimated at 84 individuals per year. Considering that the majority of birds found dead in wind farms are young, the expected number of bird losses may augment the species juvenile mortality by up to 90%. However the aforementioned figure of casualties could drop by over 60% (i.e. 28 individuals per year) if the European network of the NATURA 2000 sites was set as an exclusion zone for wind renewable developments. In both scenarios, this relatively new lethal source must be assessed at a population level in relation to other mortality factors that affect primarily adult birds and prospective breeders such as the secondary poisoning due to the illegal use of baits against mammalian vermin.

How birds have been affected by some of the first wind farms in South Africa

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Abstract

South African has a small, but growing wind energy industry. We reviewed avifaunal monitoring reports for the first eight wind farms of the Renewable Energy Independent Power Producer Programme in order to help contextualise, improve predictions, and ultimately minimise negative effects of wind energy on birds. Post-construction monitoring data included in the review was gathered at each wind farm over a period of between one and two years, using protocols outlined in BirdLife South Africa and the Endangered Wildlife Trust's Best Practice Guidelines for Avifaunal Impact Assessment and Monitoring at Wind Farms in Southern Africa.

No conclusive evidence of displacement of birds was reported for any of the sites in the study, but a more detailed analysis of the raw data (which was not available at the time of the review) would be of value. The average estimated fatality rate was 4.1 birds per turbine per year (285 turbines), and falls within the range of estimated fatality rates reported in for the United States of America and Europe. All wind farms in the review reported at least one fatality of a threatened species. Raptors accounted for 37% of carcasses found. Amur Falcon (*Falco amurensis*) and Jackal Buzzard (*Buteo rufofuscus*) made up the majority of raptor carcasses, but threatened species such as Martial Eagle (*Polemaetus bellicosus*), Verreaux's Eagle (*Aquila verreauxi*) and Black Harrier (*Circus maurus*) were also affected. Over a third of carcasses found were swifts, swallows, martins and other small songbirds.

The study reinforces the value of post-construction monitoring and information sharing, particularly where wind energy is developed in new environments. The results are based on a limited number of wind farms and short time period and should therefore be considered preliminary, but have already provided useful information for site screening and impact mitigation at wind farms in South Africa.

Vulnerability index for Western Palearctic soaring birds regarding wind farms placed on migration flyways

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Abstract

Wind farms cause bird displacement, loss of habitat and mortality through collisions. Soaring birds (raptors, storks, pelicans and cranes) are especially susceptible to these impacts because of reduced flight maneuverability (in some species), frequent flights at turbine height and large overlap of wind farm locations with migratory flyways and bottlenecks. Furthermore, some of these species occur in reduced numbers, and most of them exhibit delayed maturation and produce few offspring annually, increasing the relevance of an additional mortality source at a population level.

Given the increasing number of wind farms being developed along soaring birds' migratory flyways, including important bottleneck locations, it is important to assess population-level impacts on these species. Here we propose an approach to assess aspects of soaring bird ecology which influence population vulnerability to wind farms located on migratory flyways, also taking into account the conservation importance of each species. For this, we developed a vulnerability index for each soaring bird species present in the Western Palearctic, which incorporates variables such as flight altitude, maneuverability, ability to detect turbine blades, nocturnal flight activity, gregarious behaviour and degree of concentration at bottlenecks. Data used for scoring these factors came directly from large datasets of soaring bird migration obtained from long term monitoring programs at wind farms located in important bottleneck sites in the western Mediterranean flyway (Sagres, Portugal) and the eastern Mediterranean / Rift valley / Red sea flyway (Gulf of Suez, Egypt). Considering both study areas, information was gathered for 90% of the species that occur in the region. This information was complemented with a review from the literature and a consultation to a group of experts. Conservation importance, for each species, was scored taking into account biogeographical population size, adult survival rate and European and Global conservation status. Each of the ecological and conservation factors was scored on a five point scale (1 - low vulnerability to soaring birds to 5 - high vulnerability to soaring birds).

We hope that this approach will help in identifying likely impacts of future wind farms on migratory soaring birds, while providing a useful tool for producing sensitivity maps, regarding wind energy projects, for strategic environmental impact assessment along migratory flyways.

A circus of uncertainty: collision risk and hen harriers, *Circus cyaneus*

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Abstract

Avian mortality as a result of collision with turbine blades is an important concern with the development of wind farms. Such impacts are usually assesed through the use of collision risk modelling, although validation of these models has been infrequent and any biological sense checking of the parameters underpinning the model scant. The hen harrier, *Circus cyaneaus*, has typically been considered as a species of low risk of collision, largely as a consequence of its low flight height during foraging. However since becoming operational in 2012, a wind farm in Perthshire, Scotland, has resulted in four hen harrier mortalities through collision, despite there being no risk predicted during the Environmental Impact Assessment process. As a result of the initial mortalities we untook research to investigate the flight characteristics of hen harriers in the vicinity of the wind farm and at two control sites to attempt to understand the mechanisms behind these fatalities and to better predict the risks for future development.

We developed a system of tracking the movements of harriers in three dimensional space using two observers, each using a viewing platform that combined conventional optics with data loggers, clinometers and digital compasses. These data were combined using trigonometry to map the harriers movements, and to derive key parameters of collision risk modelking such as flight height and speed. An initial check of the accuracy of the technique was carried out using a drone fitted with a barometric altimeter. The results of this validation exercise indicated that the accuracy of the method was high.

The mean (least square mean $\pm$ SE) flight height of hen harriers across the sites was 33 ($\pm$5) and 41 ($\pm$5), respectively. The flight height was significantly associated with sex of the bird (males on average flew higher than females; 45 m vs. 28 m above ground) and flight type (display and soaring flights, general flights, hunting flights and interaction with other species). Flight height was not significantly associated with study site, year and month. Flight height was also significantly associated with habitat (highest above woodlands), aspect (highest above north-facing aspects) and slope (declining flight height with increasing

steepness). These measured flight heights corresponded with a far greater collision risk than that previously derived from estimated flight heights.

Preliminary analysis of flight speed data has shown that flight speeds are typically slower than those used in collision risk modelling and therefore carry a greater predicted collision risk. Flight speed varied across flight types, such as foraging and displaying.

These results demonstrate that conventional impact assessment techniques may seriously underestimate the potential risk of mortality through collisions for harriers. This is in part because the assumption that harriers fly close to the ground, as applied to numerous risk assessments is wrong; they only forage close to the ground. As described by our data, harriers spend a considerable amount of time at collision risk height, and this is largely associated with flights related to breeding behaviour. Flight speed, an important parameter in collision risk modelling is also consistently misparameterised. We suggest how improved survey techniques and better parametrised modelling can prevent the impact of collisions being so profoundly wrong.

Accounting for regional bat phenology and turbine characteristics significantly improves models that predict bat collisions at wind turbines

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Abstract

Bat fatalities at wind turbines have often resulted difficult to predict, mainly because the species of bats affected are highly mobile and opportunistically follow the insects they feed on. The activity of bats in the rotor swept area of wind turbines is, hence, highly variable in time and space. Moreover, the effect of various turbine characteristics as height and rotor diameter on fatality rates remains poorly understood. It is crucial to accurately predict when, where, and how many bats are being killed in order to effectively mitigate the adverse effects of wind energy production on bats.

We use regional phenology patterns of bat activity in a statistical modelling approach to more precisely predict fatalities of bats at wind turbines in Central Europe. We also included the height and rotor diameter of turbines in the model to quantify the effect of these parameters on the collision rate of bats.

Our analyses were based on acoustic bat activity data sampled at the nacelle of wind turbines and simultaneous fatality searches. Acoustic data were sampled during 26,900 detector-turbine-nights at 110 turbines (2 to 4 turbines per site, nacelle heights between 60 and 140 m, rotor diameters between 66 and 126 m) in six years between 2007 and 2015. Turbines were sampled between March 21st and December 30th with one or more of three different bat detector types (Batcorder, Anabat SD1, and Avisoft/BATmode). In total 90 dead bats were found below the turbines during 2701 early morning fatality searches.

We used hierarchical N-mixture-models to predict the number of fatalities for a specific night (or year to analyse the effect of turbine charactersitics) at a turbine from the acoustic bat activity, wind-speed, day of year, and an indicator for species composition.

Acoustic detectors do not cover the entire rotor-swept area and bat activity may vary greatly within short time periods. Therefore, we did not directly use the acoustic activity

measured but (using a generalised additive mixed model) assumed that the phenology of bat activity was the same at turbines within each of four geographical areas covering the northern half of Germany and that the level of activity differed between turbines.

As an indicator of species composition we used the activity of Nathusius' pipistrelle, *P. nathusii*, a migratory species that differs in a number of important aspects of its ecology from the other bat species affected. Preliminary results show that the fatality rates predicted by our new model are more accurate than the ones used so far in Germany because they better account for differences in phenology, different times of the year, and species composition in different geographical areas. Rotor diameter affected fatality rates positively, while turbine height showed a negative correlation, also when controlling for the level of bat activity and wind-speed. The effect of the rotor diameter was similar to that predicted from the spatial distribution of bat activity around the nacelle of turbines measured by stereo thermal-imaging.

The new models will be implemented in the free software tool ProBat that is widely used in Germany for calculating bat friendly curtailment algorithms for wind turbines and that is now also available in English language. The resulting algorithms will be more cost-efficient than the ones used so far while maintaining the same level of bat protection.

2.2 Day 2 - September 7, 2017

2.2.1 *Parallel Session 7: Mitigation*

Multi-year operational minimization study in West Virginia: potential novel strategy to reducing bat fatalities at wind turbines

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Abstract

Limiting blade rotation at relatively low wind speeds (e.g. <5.0 m/s or <6.5 m/s) has proven to be successful in reducing bat fatalities at wind turbines. Yet, this operational minimization strategy appears to be cost prohibitive. Thus, strategies to reduce the economic impact to the industry, while maintaining the conservation value, are needed to maximize adoption. In 2012, we initiated a 3-year study at a wind energy facility in West Virginia, U.S., to test the effectiveness of different operational minimization strategies to reduce bat fatalities. In the first year, we tested normal turbine operation (3.0 m/s cut-in; control) versus turbines that were feathered below 5.0 m/s for the first four hours of the night (5m/s-half-3min) and the entire night (5m/s-all-3min), with all operational changes based on 3-minute wind speed averages measured at the meteorological (met) tower. In 2013, we tested normal turbine operation versus increased cut-in speeds of 5.0 m/s all night (5m/s-all-10min) and 6.5 m/s all night (6.5m/s-all-10min), with operational changes based on 10-minute wind speed averages measured at the met tower. In 2015, we used 5.0 m/s all night based on 10-minute wind speed averages at the met tower (5m/s-all-10min-met) as an alternate control group since that operational adjustment was already being implemented as a minimization strategy at the site during the autumn migration period. We compared this alternative control group to two treatments using 20-minute wind speed average measured either at the met tower (5m/s-all-20min-met) or at each individual turbine (5m/s-all-20min-turbine). In 2012, we found a significant difference between 5m/s-all-3min and the control group, but no difference between the control and the 5m/s-half-3min treatment. In 2013, we found a significant difference for both the 5m/s-all-10min and 6.5m/s-all-10min treatments versus the control, but no

significant difference between the two treatment groups. In 2012, the 5m/s-all-3min showed an average 47% and in 2013 the 5m/s-all-10min showed a 58% and the 6.5 m/s-all-10min treatment showed a 75% reduction in bat fatalities. In 2015, our results indicated significantly fewer bat fatalities occurred when turbine operations were based on the met tower rather than individual turbines. Furthermore, extending the decision time, from 10 to 20 minutes, to initiate start-up, may have contributed to lower fatalities by reducing the number of transitions (i.e., turbine start-ups and shut-downs). Minimizing the number of start-ups/shut-downs also may assist in reducing wear-and-tear on turbines and, at least in this study, may reduce the power loss related to this minimization strategy. Thus, 5m/s-all-20min-met represented a decision framework with fewer fatalities, significantly fewer than 5m/s-all-20min-turbine, and compared to 5m/s-all-10min-met had less transitions (i.e., potential turbine wear-and-tear) with slightly more power production. Therefore, the 5m/s-all-20min-met may be the most cost effective option of the 3 treatments studied in 2015. To better determine the cost-effectiveness of this novel strategy, future research should investigate the potential of modifying traditional operational minimization strategies by increasing the decision time to initiate turbine operation in other regions and as an alternative to raising the cut-in speed greater than 5.0 m/s.

Mitigation strategies & effectiveness - the Candeeiros wind farm monitoring and mitigation program case study

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Abstract

Wind farms development, while presenting many advantages in the reduction of carbon emissions, are also known to have negative impacts on wildlife, namely direct bird fatality. Raptors and other soaring birds have some of the most affected species, either because of their behavior, conservation status and small populations. In Portugal, it is common to have wind farms' monitoring programs specific to these target species.

Candeeiros wind farm, located in central Portugal, has been monitored since its construction phase in 2005, when a monitoring program aimed at the general bird community in the wind farm area was implemented. By the end of 2008, the fatality estimates obtained (based on observed mortality) showed that common kestrels *Falco tinnunculus* were having high mortality rates due to turbine collision, which could be impairing the local population. Given these results the monitoring program was adapted, and aimed specifically at common kestrels in order to estimate its population, which showed that it was bigger than initially foreseen. The mortality rates, however, remained high in the following years and by the end of 2012, Bioinsight and the wind farm developer advanced to the implementation of a site-specific mitigation program to Candeeiros wind farm, according to the characteristics of the study area and ecological requirements of the target species, to try and reduce this impact.

The mitigation program aimed to reduce the mortality of the species, by using habitat management techniques. In the vicinities of the turbines with higher mortality rates we took measures to decrease the habitat suitability for the kestrels' presence, aiming an impact minimization. Since the kestrel usually hunts in open lands we promoted vegetation densification through the plantation of a native shrub species - the kermes oak *Quercus coccifera*. On the other hand, habitat management also included an effort to favor biodiversity (and preys) and suitable vegetation structure for kestrel usage in areas outside the wind farm turning them more attractive for the bird, as a compensation for the habitat loss near the turbines.

We overview the monitoring results that led to the implementation of the mitigation program. Despite an observed reduction in kestrel fatality since 2013, it is still soon to take conclusions on the mitigation program efficiency itself, since the *Quercus coccifera* survival rate were low. Those that survived are still in a precocious development phase, but we reflect upon it, approaching the obstacles and difficulties we found, and the strategy to adapt and improve the current measures to assure the long-term success of the program, in the light of the PDSA cycle (plan-do-study-act).

We also defined a stakeholder's map and overlook the partnership dynamics with authorities, local institutions, land owners and shepherds, that took place and are crucial to the success of mitigation and compensation programs.


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Efficiency of RADAR-assisted wind turbines selective stop Programs on migratory routes in SW Portugal

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Abstract

The program of RADAR-assisted wind turbines selective stop, has been implemented since 2015 in a set of wind farms in Portuguese SW, with the objective of minimizing the direct impacts of these projects on the migratory soaring birds.

To this end, the migratory movements of the soaring birds in the zone of implementation of the projects and their surroundings are closely monitored, with particular attention to species with a high interest for conservation.

The monitoring is performed by a team of experienced ornithologists, assisted by a RADAR system for detection of flocks to great distances. Birds follow-up is conducted between 15 August and 30 November, throughout the daytime period.

The system of wind turbines is fired whenever, met certain criteria, there is the entrance of birds in the security perimeter, calculated considering the speed of progression of the birds and the time required between the stop order and its effectiveness.

The results show that the area is used by more than 30 soaring species, of which 21 have unfavourable conservation status. We stand out the species Black Vulture (*Aegypius monachus*) and imperial Eagle (*Aquila adalberti*), critically endangered; and Golden Eagle (*Aquila chrysaetos*), Bonelli's Eagle (*Aquila fasciata*), Montagu's Harrier (*Circus pygargus*), Egyptian Vulture (*Neophron percnopterus*) and Osprey (*Pandion haliaetus*), in Danger.

Among the various observed species, the species Griffin (*Gyps fulvus*), classified as near threatened, is the one that uses the territory more densely, corresponding to approximately 85% of the total registered birds.

The results allowed a detailed mapping of the migratory route of the different species and their variation in function of specific meteorological factors.

Regarding the effectiveness of the program in minimizing the direct impacts, the results demonstrate the effective reduction of mortality, for values considered negligible.

This program demonstrates that it is now possible, with the aid of this type of systems, or by using pattern recognition technology, to calibrate detection systems capable of effectively preventing bird and bats mortality. Where before the presence of threatened bird communities and bats made the implementation of wind farms incompatible, it is now possible to design impact minimization systems that make projects viable.

Could the smooth surfaces of tower monopoles be a contributing factor to bat fatalities at wind turbines?

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Abstract

One proposed explanation for why bats are coming into close contact with utility-scale wind turbines is that the turbines provide or may be perceived to provide one or more important resources. As previous studies have shown that echolocating bats misidentify artificial smooth surfaces to be water, we hypothesized that 'water misperception' could be contributing to bat activity in the immediate vicinity of wind turbine towers, thereby putting bats at risk of colliding with rotating blades. Since 2012, we have been investigating the potential link between bat behavior at smooth surfaces and bat fatalities at wind turbines. Using thermal cameras and night vision technology, we found that bats approach wind turbine towers with the same head-first posture as bats drinking at water. Furthermore, the results of a playback experiment revealed that characteristics of synthetic bat calls returning from water were virtually indistinguishable from those returning from smooth tower surfaces. Building upon these observations, we designed a series of flight room experiments to evaluate the behavior of wild-caught bats at a range of smooth and texture-treated surfaces. The overall goal of these experiments was to identify a texture treatment that bats show little or no interest in approaching and that could be applied to operational wind turbine towers. In these flight room experiments, both eastern red (*Lasiurus borealis*) and evening bats (*Nycticeius humeralis*) responded differently to smooth and texture-treated surfaces. With experimental surfaces (flat and curved) in a horizontal position, we found that bats contacted the smooth surfaces, but did not contact the texture-treated (made with paint additives) surfaces. Nevertheless, the number of bat passes $<$1 m appeared to increase as the texture gradient increased, indicating that bats began to show more interest in surfaces with larger gap sizes between particles. Based on these results and on an analysis of the acoustic properties of bat echoes from smooth and textured-treated surfaces, we designed a texture-treatment involving a paint additive with particles of more than one size category. When this treatment was applied to experimental surfaces (flat and

curved) in a vertical position, we observed significantly fewer passes <1 m at the texture-treated compared to the smooth surfaces. The results of these studies indicate that we have identified a texture treatment that when applied to the tower surface could provide a means of reducing bat activity near the tower, i.e., in and around the rotor-swept zone. If the predicted reduction in bat activity also leads to a reduction in bat fatality, this texture treatment may be an effective mitigation strategy that does not incur a loss of power production.

Visual mitigation measures to reduce bird collisions - experimental tests at the Smøla wind-power plant, Norway

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Abstract

Wind-turbine induced bird mortality is due to physical collisions, but so far no effective deterrent or mitigation measures have been developed. Development of practical and functional tools, measures or products to reduce bird mortality related to wind energy production is therefore of great importance to preserve vulnerable bird species, and also to improve public acceptance of wind energy production.The INnovative mitigation Tools for Avian Conflicts with wind Turbines (INTACT) project set out to investigate various mitigation measures to reduce bird collisions at the Smøla wind-power plant in Central Norway. This plant was built in two phases; the first phase was finished in 2002, while the second phase became operational in 2005.

Here, we present tests of the efficacy of contrast painting one of three rotor blades black, and of painting the lower 10 m of the turbine tower black to reduce avian collisions. Our hypothesis was that the painting would increase the visibility of the rotor blades due to a reduction of motion smear and of the tower due to increased contrast against the background, and that this would lower the collision risk.

Primo August 2013, the rotor blade painting was applied at four turbines with previously recorded collisions. Neighbouring turbines were defined as control turbines. In Mid August 2013, four towers were painted, while six additional ones were painted ultimo July 2015. Collision data were collected using trained dogs until end 2016. The number of recorded collisions were compared between the painted and control turbines before and after painting (BACI design), while taking into account search effort by including an offset term and random clustering over turbines and years using a generalized linear mixed-effects model with Poisson distribution. To assess the potential effect of painting across spatial scales, bird activity was recorded using avian radar, rotor blade (near-) collisions of birds were recorded by video detection equipment (DTBird) installed on two turbines.

The avian radar data indicated that number of birds present was significantly reduced at the painted turbines after the treatment. The video system DTBird installed at one rotorpainted and one control turbine, showed that the weekly number of near-turbine observations of white-tailed eagles, using a cocktail of statistical tests for reason of comparability, was lower at the painted turbine relative to the control turbine.

The generalized linear model indicated that the annual number of bird collisions after painting of the rotor blades was significantly reduced, especially during spring.

The generalized linear model also indicated that the yearly number of ptarmigan collisions after painting of the turbine towers was significantly reduced at the painted turbines.

Our results provide support for that simple mitigation measures as painting rotor blades and tower bases can significantly reduce bird collision risk by enhancing the turbine's visibility. Such measures should therefore be implemented during the construction and repowering of wind-power plants. Although the costs for implementing such measures during the operational phase are relatively much higher, they should be considered at high-risk sites.

2.2.2 *Parallel Session 8: Impact monitoring & Risk assessment I*

Combining radar measurements and carcass searches: Number of bird fatalities and relation to migration intensity at a wind farm in a mountainous area

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Abstract

The solutions discussed in Switzerland to reduce the number of collisions of birds migrating on a broad front included the proposition to temporarily shut down wind turbines when migration intensity is high. In order to define measures that can be integrated into the authorisation procedures for wind power projects, it is essential to understand the relationship between the number of birds theoretically exposed to collisions and the number of birds which effectively collide. The only suitable method for determining the number of birds passing a certain location is the detection of birds using quantitative radar measurements. To our knowledge, the present study is the first one that combines a systematic carcass search study with simultaneously conducted quantitative radar measurements using a radar device calibrated for bird detection over several months.

Between 01.03.-15.11.2015, the ground below the three wind turbines (Enercon E-82, hub height: 108 m) of a wind farm in the Jura mountains (∼1100 m asl), was systematically searched for bird remains on 85 days (on average every 2.8 days). Three correction factors were considered for the extrapolation of the number of collision victims: search efficiency, persistence time of carcasses, and the probability of a carcass lying within the searched area. Migration intensity was recorded continuously (24 h) during 265 days (26.2 - 17.11.2015) using the radar BirdScanMT1.

Collision victims mainly belonged to nocturnally migrating small passerines, especially Fire- and Goldcrests (*Regulus sp.*). The absolute collision rate was 20.7 per wind turbine (CI-95%: 14.3 - 29.6). The relation of the extrapolated number of collisions to the number of birds theoretically exposed to a collision (based on radar data) showed that 2% of the birds theoretically exposed to a collision were effectively colliding, which corresponds to an avoidance rate of 98%.

The study area is characterised by distinct migration intensities. Collision events mainly occurred during migration periods. Within migration periods, the allocation of collision events with specific migration intensities was limited due to the carcass search intervals of 2 to 7 days and the unknown instant of collision. However, there were periods with strong migration and no carcasses. We therefore assume that additional factors influence collision risk. Most likely limited visibility due to meteorological conditions could be of major importance. Combining migration intensity and visibility could be a suitable approach to predict real collision risk for migratory birds.

Wildlife Monitoring and Reporting System using Operations and Maintenance Personnel: 5-year Assessment

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Abstract

This study is the first investigation of the validity of a long-term Wildlife Monitoring and Reporting System (WMRS) using operations and maintenance (O&M) personnel to assess potential operational impacts (numbers, species composition, trends) to wildlife resources from wind plants across the United States.

The goal of the program is to achieve a level of sensitivity that assesses impacts to wildlife integrated with everyday maintenance while encouraging wildlife awareness. The objectives related to birds and bats fatalities were:

- Document numbers of fatalities and identify large (>5) fatality events;
- Document species composition;
- Determine trends at wind plants.

This presentation focuses on the first five-year assessment (2011-2015) of long-term operations monitoring to meet these objectives. WMRS is completed through voluntary, long-term monitoring conducted by O&M personnel recording wildlife injuries and fatalities at fleet-wide plants. Long-term monitoring consists of: 1) Environmental Coordinator (EC) inspections (standardized weekly searches in fall and spring) along access roads and pads ($>$ 17,900 inspections), 2) monthly turbine checks of base pads ($>$ 170,000 checks), and 3) incidental observations fleet-wide (2015 - 48 plants). Bird and bat fatalities were evaluated and compared for bird/bat detection rates and large events ($>$ 5 fatalities), species composition (over 200 post-construction fatality studies), and trends (EC inspection detection rates with published fatality rates). A key factor on validity of the methods is testing searcher efficiency. Bias trials of O&M personnel were conducted in 2010 to evaluate their detection of fatalities during EC inspections at four sites in the US. Detection levels were 76% (105 of 139). This reinforced the use of operations personnel.There were no large events, and there were low numbers of detections per search. More bats than birds were found during EC inspections than incidentals reflecting spatial occurrence of fatalities and their detectability. Species composition

of birds and bats was broadly similar to species composition from other wind plants. The overall seasonality of discoveries during turbine checks and incidental observations for overall species composition was broadly similar to national patterns. Detection rates from long-term monitoring were weakly correlated to comparison sites but there was a significant correlation ($p < .0001$) between the median number of bat fatalities found during EC inspections and fatality studies at similar plants. This suggests that detection rates for long-term monitoring may be useful as a broad index to overall fatality rates or detecting large fatality events. There was little evidence for trends in detection rates, and no evidence for increasing trends in detection rates. The assessment demonstrates that long-term monitoring using trained O&M personnel provides an indicator of wildlife impacts, presents a sensitivity to trigger responses, and is a valid approach for understanding impacts at operating assets. Examples of adaptive management and measures for European consideration will be presented.

Red Kite collision risk objectivities, an issue for wind project acceptance

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Abstract

When species as Red Kite is present in a project area, the social acceptance is often difficult because of issues linked to endangered bird species population conservation. In this case it appears necessary to introduce objective result in the debate to support the project if justified or to explain to the developer that the project can not be developed because of a high biological impact level.

Those considerations lead to develop risk objective analysis adapted to project conditions.

Based on two biological consideration verified by the contrary hypothesis:

- bird territory occupation is not aleatory at a the territory scale,

- bird displacements are aleatory at displacements in the territory scale,

The collision risk can be evaluated taking care to the physically component of the project (number of turbine, project area, turbines height, angular speed average, landscape occupation and turbine localisation) and taking care also of the biological data relative to the bird etho and ecology (flight height, flight quantity per height, presence duration along the year, flight localisation looking the landscape occupation, specifically avoidance rate,...).

Those data integrated in collide probabilistically calculation allow proposing a collision risk indicator:

The probability that a bird flight across a rotor area during a definite time, and the probability that a bird flying across a rotor would (be) collide.

This indicator based on bird project area occupation and project definition allows modifying and comparing different project design to develop the less risky one or to abandon it in case of too much strong mortality risk.

This probabilistically approach can be declined for different species, at the condition of a well definition of the flight quantity indicator. If for a Red Kite flying to feed this indicator is the surface flown (length flight, time flew cross to the flying speed and the bird area) in case of bird which would cross wind turbines lines as for Black Stork, this indicator would be the number of crossing flight.

Despite a specifically data collection strategy need to be defined project by project to collect the useful data for risk calculation accorded to the bird conservation issue.

Risk assessment of wind turbines for nocturnal migrating birds - a radar study within a world-renowned bottleneck in Israel

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Abstract

Most risk assessment studies for wind farms focus on diurnal soaring birds and do not include the vast majority of migrant birds that pass during the night. We conducted pre-construction environmental assessments at four proposed wind farms in Israel, in order to assess the risk to broad-front migrants (mainly waterbirds and Passerines) that may make up to 99% of the total migration volume. Fixed-beam vertical radars (Birdscan MR1, Swiss Bird Radar Solutions) were located at each of the sites across the country for a period of one year (two complete migration seasons). Two of these sites are along the Rift Valley, a world renowned migration bottleneck.

The radars recorded bird echoes up to the height of 600 - 1,500 meters (depending on target size), which were classified to several classes (insects, passerines, waterbirds, etc.) and converted to a standardized "Migration Traffic Rate (MTR)", expressing birds/km/hour. The MTR was calculated for 100m height intervals, enabling the calculation of the numbers of birds that are flying at low altitudes and hence at potential risk from wind turbines. The actual number of birds at risk was further calculated according to wind conditions measured at each site.

The results provide new perspectives for understanding bird risks at wind farms. Although eliminated from further analysis, insects predominated echo numbers in most of the stations, accounting for 47 - 76% of the total echo volume (emphasizing the importance of a reliable echo classification in such radar studies). Total bird numbers (per kilometre) varied between 1 - 2.3 million birds per site and migration season. Migration density through the Rift Valley sites was greater on average, with their annual totals (combining the two migration seasons) being between 3 to 3.5 million birds per km, compared to 2.5 - 2.8 million in the other two sites. However, the number of birds passing within the low-altitude risk zone appeared to be correlated to local topography (site altitude above sea level), hence a proportionately lower number of birds at risk within low laying valleys versus mountain ridges.

Migration heights also varied greatly between the current study and the results of a former radar study carried out in southern Israel by the Swiss Ornithological Institute during the early 1990s. The 1990 study reported that spring migration is much higher than in autumn, whereas we found a higher proportion of low flying birds in spring. In addition, bird totals in autumn were about two times higher than in spring in southern Israel in both of the studies (current and former), while in northern Israel we found the opposite relations, with spring migration being almost two-times stronger.

Overall, the radar methodology used in this study enabled the estimation of the number of birds at risk and their general class composition at specific locations. Due to the small aerial search volume of the radar, it cannot be used for diurnal soaring birds that tend to concentrate along narrow corridors. The relationship between total numbers of birds passing through the area and the actual collision risk is a necessary next step in developing risk assessments based on radar studies.

Gabel Al-Zayt wind farm post-construction monitoring for non-operational windfarm for spring survey, 2014, Gulf of Suez, Egypt

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Abstract

The Gabel Al-Zayt wind farm is a 200MW, KFW-funded project located at the western bank of the Gulf of Suez, It is a bottleneck Important Bird Area (IBA) for bird migration, at the heart of the Rift Valley/Red Sea flyway; the second most important flyway for migratory soaring birds (MSBs) in the world. Egypt is targeting 20% of its energy needs to be met by renewable energy by 2020, with the majority of this commitment to be realized through the extension of wind farm projects, hence there is a real potential for interaction between wind developments and MSB's with the potential for negative impacts on MSBs. Appropriate assessment will identify likely impacts and suggest the need for mitigation actions which should be undertaken in the operation of farms to minimize impacts.The main purposes of this post construction monitoring of non-operating wind farm are to monitor the movements and behavior of soaring birds in the windfarm, assess potential collision risk, and assess the applicability of the shut-down criteria. Moreover, on-job training of Egyptian team was aimed at strengthening the local capacity to undertake future monitoring and assessment of the site. During the standard field observation, a total of 525,246 individuals were recorded belonging to 32 species of migratory soaring birds, during 1550 observation hours. The majority of all individuals belonged to only few species (White Stork 61.6%, Steppe Buzzard 10.8%, Levant Sparrow hawk 9.3%,and Honey Buzzard 6%), other species occurred in comparable low numbers.

Though the survey was conducted for half spring migration season, it confirmed the sites' international importance for MSB migration in terms of soaring birds' migration and percentage of flyway population. General flight patterns of MSB are weather dependent and differ with time, the most frequent movement pattern is where birds observed drifting with northern wind toward the southeast at low altitudes in the early mornings, then heading north wardly at high altitudes later in the day, suggesting multiple counts of birds. The majority of White

Pelican flocks were recorded in the wind farm Red Area were flying below 200m, which makes them more vulnerable to collision risk. Broad fronted migrant and species that regularly feed when migrating (falcons and harriers) were generally spending more time in the wind farm and fly at risk height. In addition, other site management, operational, and monitoring recommendations were proposed to minimize impacts of wind farm development on the globally significant bird migration in Gabel Al-Zayt area, of particular importance recommendations to minimize disturbance to roosting birds and increase visibility of turbines, while coupling Shut Down on Demand SOD with post-construction monitoring to assess its effectiveness and inform potential intervention options to minimize or eliminate impacts.

2.2.3 *Parallel Session 9: Planning & Policy I*

Environmentally Sound Development of Offshore Wind Energy by Implementing a Good Practice in Impact Assessment, Mitigation and Compensation

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Abstract

First, the state of knowledge on ecological impacts of offshore wind energy is presented. Second, necessary mitigation and compensation measures for an environmentally sound development of offshore wind energy are introduced.

Presenting the state of knowledge on ecological impacts of offshore wind energy: To reach a synopsis of the ecological accompanying research on offshore wind energy, results of international research on possible impacts on fish, benthos, resting and migrating birds and mammals are investigated.

An increase of benthos and fish and a change of the composition of the species is noted after construction. The distribution of resting seabirds changes substantially as a result of offshore wind farms (OWFs): some bird species avoid OWFs, whereas others ignore them or are attracted to them. Migratory birds show displacement and anticipatory evasion behaviour towards OWFs and avoid the zone of the rotor blades. Significant effects on migratory birds have not yet been verified, but at night or in bad weather situations possible fatalities are difficult to accomplish due to a lack of technology.

Harbour porpoises can be impacted during the period in which turbines are rammed because of the damage to their hearing. With the use of mitigation measures no injured mammals and no long-term impacts on the numbers of porpoises have been found. During operation of OWFs, the abundance of harbour porpoises was shown to be similar to the period prior to the construction of the OWFs.

Research motivations and objectives, including the specific hypotheses being tested: The research on the effects of OWFs has been carried extensively over the past 10 years. What was missing so far was a synoptic collation of the results which is presented in the first part.

Especially in Germany, extensive preventive measures and mitigation measures have already been implemented as part of the construction. Therefore, the effectiveness of these measures was analyzed in part two.

The hypothesis should be, that the development of offshore wind energy can be achieved in an environmeally sound manner.

Design, methodology and statistical analysis: The results of the presentation mainly came from the author's PhD thesis on '*Strategies for an Environmentally Sound Development of Offshore Wind Energy*'. The results of the PhD are based on published data collected in Germany from the last ten years and international research. To validate the outcomes, experts were interviewed by Delphi method (with questionnaires and personally conducted).

Findings and Management implications: The above mentioned hypothesis of a possibility of an envrionmentally sound development of offshore wind energy could be clarified. Impacts can largely be reduced by technical means, while impairments, that cannot be avoided, at least could be compensated. The development of offshore wind power is therefore possible while maintaining the *status quo* of nature. But there is a need of an effective marine spatial planning with the aim of the exclusion of hot spots of relevant species. Next the application of state of the art mitigation measures especially against underwater noise is proposed. Furthermore, there is a necessity for more effective environmental investigations. The EIA should focus on decision-relevant subjects of protection and needs thresholds for the approval process. Last but not least, the introduction of marine compensation measures is strongly indicated.

Tracks, maps and marine renewables: understanding seabird distributions at sea in relation to risk and spatial planning

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Abstract

Marine ecosystems are very likely to be impacted by changes in climate and one of the key benefits of renewable energy is the reduction in the magnitude of such changes. However, when choosing where to site marine renewables there needs to be a balance between mitigating the risks associated with climate change and those risks posed directly from new technologies being placed in the marine environment. Therefore, better information on seabird distributions at sea is vital to making planning decisions about the locations of and risk posed by offshore renewables.

Currently, maps of seabirds distributions in UK waters are available, derived from boat and aerial transect data. Another source of data is individual tracks from GPS-tagging, which provide valuable information, such as locations of foraging areas, distances travelled, and provenance of birds at sea. Tracking data can also be modelled to produce maps of wider seabird distributions at sea, adding to those currently available. Understanding how multiple sources of information of seabird distributions compare can help maximise confidence in the relative importance of areas of sea for seabirds. In turn this will help improve our understanding spatial risk related to marine renewables.

We have used GPS-tagging data collected in the UK to produce at-sea model-based distributions. Here we present two types of comparisons of tracking-derived maps to existing maps derived from transect data sources. Firstly, for four species, we compared areas of higher use from existing at-sea distribution maps covering UK waters, to areas of higher use from tracking derived distributions. Secondly, for two species, we compared at-sea distributions derived from simultaneously collected data from tagged birds and from at-sea boat surveys, over a limited study area, we found that, despite multiple differences in the properties of the datasets, levels of agreement were high, in both sets of comparisons. This strengthens the evidence base for consistent at-sea areas of higher risk. Comparisons, also indicated that locations of and distances from colonies were important in determining agreement in these

comparisons. For example, in UK-wide comparisons, concordance between areas showing higher usage was greatest close to colonies.Our results suggest at-sea areas most likely to be used by seabirds at sea during the breeding season can be consistently predicted between data sources, providing the first steps for a more reliable assessment of spatial risk, based on corroborative evidence.

GIS-based methods for sustainable wind power planning

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Abstract

Research motivation: Renewable energy has great importance in the work to counteract the global climate changes. The Swedish government has set a target that in 2020, 50% of the energy use shall come from renewable energy, and the government has also declared a long term commitment for Sweden to be independent of fossil fuels. To reach these targets wind power is expected to play a great part, and approximately 50 TWh of new wind power is needed to meet this objective, compared to the current annual production of approximately 16 TWh. However, climate change is not the only issue at hand, and there is a risk of conflicts between meeting the targets for renewable energy and other sustainability objectives, e.g. concerning ecosystem services, such as habitat supporting biodiversity, recreation and cultural landscapes. Hence to steer towards a sustainable planning of wind power, targets and objectives as well as decision support has to be dealt with systematically, encompassing social, economic, technical and ecological perspectives.

Objective: The objective of the project is to develop GIS-based methods that can be used as planning support in sustainable planning of wind power, in cooperation with regional and municipalactors. The method will function as decision support, which will help planners and decision makers at local and regional level to systematically handle the different aspects related to wind power localisation.

Methodology: The project is performed in collaboration with the County Administrative Board of Västernorrland County, which is the study area for the project. Initially, a literature study is performed to gain knowledge about earlier research in the field and identify important factors to include in the methodology. Workshops are held with the included actors, to gain further understanding of what information is relevant when planning for wind power, and to gain local knowledge about the study area; what issues are at hand, and what factors govern wind power planning in the particular area. During the workshops different scenarios related to the planning process are also developed. The method will include the development of a

number of GIS-models to be used in a multi criteria analysis that can be used for design and evaluation of the different planning scenarios.

Preliminary results: The literature study as well as the workshops reveals that the location of wind turbines often can have impact on, and render conflict between, different interests and objectives. Factors of high concern when planning for locating wind turbines in the county of Västernorrland are, besides wind speed and technical considerations; noise impact, visual impact, and impact on certain birds, reindeer hearding and recreation. In order to handle these factors, multi-criteria decision analysis within a GIS environment can support planning in complex problems, with capabilities to handle multiple and often conflicting objectives, and to find sustainable solutions to decision-making problems.

Management implications: The project will result in a General GIS-based Planning Support (GPS) methodology to integrate important sustainability issues in wind power planning, which can be applied generally in future spatial planning. The project will contribute to a more predictable planning process, where disparate sustainability targets will be handled in an integrated and systematic way, thereby increasing the possibility of reaching the targets.

Bat conservation at wind turbines: German experts discordant regarding performance of established approval and implementation planning processes

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Abstract

Over the past decades, wind energy has continuously been promoted as an environmentally friendly alternative to conventional energy sources, however, with time, considerable conflicts between wind-energy and wildlife species became evident. Currently, relatively large numbers of protected bats die at wind turbines (WT) across Europe calling for immediate conservation action at international levels. In Germany, impact assessments conducted within the framework of WT approval planning shall identify and prevent potential WT-wildlife conflicts before WT are established and mitigation measures may be obliged (approval conditions) to minimise evident conflicts during the operational phase. However, implementation of impact assessments into the approval process has never been evaluated. For this reason we conducted a nationwide stakeholder survey, asking questions on the perceived performance of established practices. Here, we show and discuss responses to our questions related to (a) the suggested (consultants) and obliged (authorities) monitoring surveys for quantifying bat activities and mitigation measures (turbine curtailment), (b) the sufficient surveillance of adherence to approval conditions, and (c) the number of lawsuits arising from WT-bat conservation conflicts. Furthermore, we illustrate and discuss the current licensing workflow in Germany identifying pitfalls from the conservation perspective. We found substantial variability in the way how stakeholder groups perceive the current situation and identified a general lack of transparency regarding baseline data on numbers of WT currently operating under mitigation obligations. Further, in the current practice of WT licensing, species conservation often ranks second or even last, hampering not only conservation efforts but also resulting in investment losses for companies due to delayed or refused approvals.

Framework for strategic wind farm site prioritisation based on modelled wolf reproduction habitat in Croatia

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Abstract

In order to meet carbon reduction targets, many nations are greatly expanding their wind power capacity. However, wind farm infrastructure potentially harms wildlife, and we must therefore find ways to balance clean energy demands with the need to protect wildlife. Wide-ranging carnivores live at low density and are particularly susceptible to disturbance from infrastructure development, so are a particular concern in this respect. We focused on Croatia, which holds an important population of wolves, and is currently planning to construct many new windfarms. Specifically, we sought to identify an optimal subset of planned wind farms that would meet energy targets while minimising potential impact on wolves. A suitability model for wolf breeding habitat was carried out using Maxent, based on 6 environmental variables and 31 reproduction site locations collected between 1997 and 2015. Wind farms were prioritised using Marxan to find the optimal trade-off between energy capacity and overlap with critical wolf reproduction habitat. The habitat suitability model predictions were consistent with current knowledge: probability of wolf breeding site presence increased with distance to settlements, distance to farmland and distance to roads, and decreased with distance to forest. Spatial optimisation showed that it would be possible to meet current energy targets with only 31% of currently proposed wind farms, selected in way that reduces the potential ecological cost (overall predicted wolf breeding site presence within wind farm sites) by 91%. This is a highly efficient outcome, demonstrating the value of this approach for prioritising infrastructure development based on its potential impact on wide-ranging wildlife species.

2.2.4 *Parallel Session 10: Impact monitoring & Risk assessment II*

Is bird fatality driven by environmental features? A spatial model for Portugal

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Abstract

Bird fatality is frequent at wind farms worldwide. Such fatality events are usually motivated by collision with wind turbines (rotating blades or turbine tower) and/or with associated infrastructures. Though bird fatalities may be related with abundance, it is not consensual amongst authors, as site and species-specific variables are to be considered as well. Amongst factors identified in literature which may be related with bird collision probability, wing-loading and soaring behaviour is one of the most mentioned. These characteristics are related to the type of flight raptors conduct while using thermals (currents of hot-rising air), which form next to slope areas. Placement of wind turbines within specific landscape characteristics can help explain and determine higher risk features for the general community. Our aim is to relate bird fatality with environmental features to assist in collision risk prediction during a layout assessment stage.

Fatalities found at 15 wind farms throughout inland Portugal were collected and analysed for spatial autocorrelation (due to their aggregation at wind farms). Therefore, measures of spatial autocorrelation were calculated (Moran's I measure) in the software ArcGIS 10.4©. Using this index records were randomly selected, until spatial independence was achieved (n = 80 records). To assess the influence of environmental conditions with fatalities we combined record occurrence with ecological variables. These included terrain aspect, slope, drainage basin, evaporation (macro-scale), humidity (macro-scale), solar exposition and radiation (macro-scale), precipitation levels (macro-scale), soil type and land use. Data was analysed through generating predictive models using maximum entropy (MaxEnt) techniques in software MaxEnt 3.3.3k. A bias grid was used to correct for uneven sampling effort.

Variables found to have a higher influence in bird fatality modelling were terrain aspect, vegetation type and slope degree (AUC = 0.910 ± 0.034). Bird fatalities are more likely at NW facing sloping terrain (∼85% probability); shrubland areas (∼60% probability) and in

relatively flat areas (up to 10°- ∼65% probability). The resulting sensitivity map of these combined features show a higher concentration of bird fatality probable locations at Marão, Gerês e Barroso mountains (northern Portugal), Montejunto mountains (Western Portugal), Estrela mountains (Central Portugal), Monchique and Caldeirão mountain ranges (Southern Portugal). These results are preliminary as further refinement of the variables and species considered will be helpful in producing fine-scale management recommendations.

The results obtained indicate that bird fatality has a higher probability of occurrence at specific features. This information should therefore be used to inform wind farm micro-scale turbine design and sitting. On a second approach the analysis provides indications on macro-scale areas where fatality occurrence is higher in Portugal. Though most wind farms are located within mountain ranges in Portugal, current best practice guidelines do not require for operational phase monitoring for further than 2 years, therefore fatality occurrence may be going unnoticed. The identification of high risk areas contributes to the proposal of a national scale monitoring plan to minimize and mitigate ongoing fatalities, as well as give indications to the development of the wind industry in Portugal.

Biological monitoring of birds and bats in wind farm La Venta III in Mexico

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Abstract

Wind energy, as any other human activity, returns effects on the environment. Despite its many environmental benefits as a CO2 emissions-free source of energy, in some cases, the windmills can derive in habitat fragmentation and mortality risks for flying fauna. These effects can be managed and minimized through due planning. Therefore, biological monitoring turns into a necessity in the different stages of the wind farms, aiming to evaluate the magnitude of these impacts and to apply correction measurements when needed.

The aim of the study carried on at "La Venta III" wind farm, from IBERDROLA renovables enterprise, is to evaluate its impact on the birds and bat population through the monitoring of ecological parameters. La Venta III windfarm is located at the Isthmus of Tehuantepec region in Oaxaca, Mexico. A detailed analysis has been conducted regarding the fall 2012-sprint 2015 period for birds and the annual cycle 2014-2015 for bats.

Both communities were characterized by lists of potential species, diversity, species richness, accumulation curves, abundancy, interaction nets and collision risks. For starters, the bird's data include flight trajectories for migratory birds, and nocturnal migrators by radar, relative abundances change, and acoustic monitoring by sonograms. In addition, bat's data was gathered by fixed, and active, ultra-acoustic detection, shelters identification and corpses search. The bird's community showed high diversity with 127 species, from which 32 are migratory, 19 are protected and one is endemic and in risk of extinction. Most of the interactions were registered at a height of 0-17 meters (windmill's base level).

The flight trajectories showed windfarm avoidance. 72 carcasses were found from 24 species, most of them residents. 16 bat species were found belonging to the insectivorous (77%), frugivorous and nectarivorous (both with 11%) guilds; shelters were located outside the windfarm. The collision data highlights *Leptonycteris yerbabuenae*, a threatened species.

31 carcasses were located from 13 resident species. The carcasses collection rate was less for birds than for bats.

Landscape fragmentation shows dominance from generalist birds attracted by low deciduous forests remnants. Mayor high risks were not found at any section of the windfarm. Due to their features as resident species, they are at a higher collision risk. The abundance diminution of migratory birds in the windfarm location could be due to trajectory changes caused by the barrier effect. The conducted monitoring at the different stages of the windfarm show the habitat's compensation capability for the impacts on flying fauna not pinpointing significant affections. It is required to maintain the relict low deciduous forests for being nesting and shelter sites. The recommendation is to maintain the windmill's base vegetation free as to reduce bird's mortality due to collision. Caused by their flying heights, bats are at more risk of collision, however, data is insufficient to determine the more vulnerable species.

Bird surveys in wind turbine projects as a tool for studying migration routes

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Abstract

Israel is a major bird migration route, where approximately 500 million birds are passing twice a year - in spring and in autumn. Recently, as the wind energy industry in Israel is beginning to develop, bird surveys are conducted throughout the country to examine the species composition and intensity of bird migration. The main objective of these surveys is to assess the potential risk from wind turbines, however the large amount of data accumulated enables us to explore various migration patterns.

The surveys were conducted by experienced bird watchers at five locations in the northern region of Israel, maximally 50 km apart, and in one additional location in most southern part of Israel. Observations were held in spring and in autumn 2014-2015, for approx. 70 consecutive days, 9-10 hours per day. Gathering data from these six surveys, as well as from several other surveys of different sources, we have compared species composition, migration volume and migration altitude in over ten different sites.

Principal coordinate analysis (PCoA) examining the similarity in species composition and abundance have found a significant difference between autumn and spring in all sites. Between sites, the north-western locations differed from the north-eastern ones, consistently with the two migration routes previously described in this region. Such differences, however, were found in autumn only, while in spring the migration seem uniform throughout the region. According to the Scottish Natural Heritage collision risk model, the number of birds at risk was significantly higher in spring in all sites. Overall migration volume was similar in both spring and autumn, but migration altitude in autumn was higher than in spring and a larger portion of the birds passed above the turbine height.

Our analysis reveals important patterns of bird migration, which can be implemented in further monitoring and management of wind farms in Israel. These data can be used as a baseline for future monitoring of migrating species diversity and migration routes. It may also simplify the assessment process of future projects. As for the collision risk, these findings

suggest that the risk for migrating birds from wind turbines is relatively low in most sites, despite of the high migration intensity.

Bat activity, and edges distance, new results for new considerations?

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Abstract

Because of the wind energy development, windfarm developers are trying to propose windfarm always closer to edges. Regarding Eurobats recommendation (at least 200 m form the first edge) for wind turbines installations, this evolution in project design oblige to study precisely the relation between edge distance and bat activity to objective decision for or against a project.

We developed during one year a dedicated data collection strategy in France to analyse special relation between bat activity to edge distance.

Based on 48 940 data collected on 58 nights with 4 automatic recorders placed in the edge, and at 50m, 100m, and 200m for edge, we did mixed models to analyse this relation.

Results show that it was a very strong relation to the edge distance globally or bat, with a statistical minimum obtained at 50 m from edge. This result shows differences in different species. If for the most part of species this relation is very strong, it appears that for Serotine, the minimum activity is noted olny at 200 m and for Noctules no statistical difference appears with the distance to the edge.

The spatial occupation find some explanation in Iwata and al.(2003), which shows a similar but hardly relationed for insectivorous birds, and insect biomass repartition.

The absence of evidence for Noctules groups and a sensitivity less marked to the edge distance for Serotines looks to be explained by the fact that those species feed at higher altitude than other species as soon as the feeding resource is available. As explained by bibliography after 2-3 time edge height vertically or horizontally, insect distribution shows no specific accumulations. The windbreack effect is not looking effective after this distance, in this condition insects repartition appears to be more aleatory than on the floor where the proximity of edge creates 'wind protected' area favourable for small insects.

Our results crossed to the bibliography show a strong dichotomy of environmental conditions around edges. The close area where most part of species are present and after 50 m

from edge where the activity is mostly due to height flight species wich have a sonar adapted to insect detection in low insect density conditions.

This consideration implies that the Noctules and Serotines taxa activity level measured on the ground (or at rotor height) is looking to be certainly the better indicators to prevent collision risk.

Recommendations based on 200 m edge avoidance are also looking certainly not adapted to reduce systematically the bat collision risk. This conclusion is convergent with 'Probat' collision risk model wich for the distance to the first edge doesn't enter as a discriminant factor in spite of the activity level appears to be the most important data.

A cost and scientifically effective monitoring protocol for large bird fatalities at wind energy facilities

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Abstract

Fatality monitoring has been a primary component of post-construction surveys aimed at determining a wind energy facility's direct impacts on wildlife. The monitoring protocols should be tailored to the taxa of interest. An optimum design for bats or passerines is likely not optimum for other larger species such as eagle and other large raptors. Monitoring for eagles has become a focus in the U.S. due to the bald and golden eagle protection act and the availability of incidental take permits for eagles. As eagle programmatic take permits are issued, permit holders will be required to conduct fatality monitoring to ensure compliance with regulatory requirements. In most cases, two years of fatality monitoring may be needed; however, survey duration may be longer to assess the efficacy of additional conservation measures when implemented. Fatality monitoring can be a substantial expense for a facility, often costing thousands of dollars per turbine each year. Our objective was to develop a more cost-effective yet viable eagle and other large bird (i.e., raptor, vulture) fatality monitoring protocol that can be integrated into the regular maintenance routines of operations personnel at most wind energy facilities. A fatality estimate requires three components: 1) carcass detection rates using systematic carcass searches, 2) experimental data on carcass persistence, and 3) the proportion of carcasses expected to land in searched areas. We measured these parameters at three wind facilities in Washington and one wind facility in California. A preliminary study using feathered turkey decoys placed within 40 meters (m) of turbine bases showed that operations personnel and 3rd party biologists had similar rates of detection (both > 0.80) under these circumstances. Follow-up studies have focused on the decoy detection rates of operations personnel while conducting standard turbine maintenance checks that are typically done monthly. These checks required operations personnel to scan along roadways and exit the vehicle at each turbine base to scan the surrounding terrain with binoculars. Decoys were placed out to 150 m from turbine bases to provide greater coverage of the anticipated carcass fall area. Detection rates during the modified maintenance checks were

generally high, with over 80% detection of all decoys placed within 100 m of turbine bases across easy and moderate visibility areas. Large raptor carcass persistence, estimated using an interval-censored modeling approach, varied from 28 to 61 days. We estimate that 95% of large avian carcasses fall within 100 m of turbine bases, while 99% fall within 150 m. Using these estimates, and assuming a 30 day search interval, the overall probability a large avian carcass would be available and detected by operations personnel ranged from 0.50 to 0.69. These results demonstrate that these monitoring methods are both cost and scientifically effective for monitoring large birds, including eagles and vultures.

2.2.5 *Parallel Session 11: Trends, tools and technologies I*

The use of low ecological risk wind energy development areas analysis to facilitate sustainable wind energy deployment

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Abstract

There are currently very few regulations or requirements for the management of environmental impacts from wind energy development in the United States. In order to facilitate the deployment of renewable wind energy with minimal ecological impacts, The Nature Conservancy is providing science-based siting information to stakeholders to support wind energy development processes. Whereas developers of individual wind energy facilities should already have information regarding potential ecological impacts at their specific sites, other stakeholders in deployment and procurement of wind energy processes may not. Having such information readily available for their decision-making efforts can help reduce impacts to sensitive species and habitats, provide significant business benefits, and help achieve true sustainability in the use of wind energy.

Deploying wind energy in an ecologically compatible manner requires siting facilities in areas where wind turbines and related infrastructure minimize direct wildlife mortalities and do not displace sensitive species or degrade or fragment their habitats. Key collaborators with wind energy developers include transmission entities, utility and corporate electricity off-takers, wind energy project financiers and insurers, regulators, and organizations encouraging sustainability in wind energy development and use. The intent is to allow all wind energy stakeholders to be aware of locations of low risk for potential wildlife impacts (and conversely, areas of higher risk of such impacts) and for them to be able to make informed decisions related to their desire to finance or purchase power from specific project locations, be they in high or low ecological risk areas.

The foundational component of the analysis is a multi-layered geospatial data system that allows users to readily identify areas where ecological risks are low and wind energy potential is high. This non-regulatory, market-driven system can facilitate more rapid deployment of

renewable wind energy; avoid most serious ecological threats; minimize potential environmental review project delays; reduce development costs; reduce business risk to stakeholders such as wind energy financiers, insurers and purchasers; help assure compliance with self-imposed corporate sustainability principles, and help to protect corporate reputations of wind energy project financiers and power purchasers by avoidance of negative public relations.

The system synthesizes published scientific information on species potentially impacted by wind energy facilities, such as whooping cranes, prairie grouse, bats, and eagles. Also included are habitats (and their inhabitants) which could be potentially impacted by wind facilities, such as very high quality playas (temporary, shallow water bodies), major wetlands, protected wildlife areas and intact native grasslands and forests. The layered analysis maps are easy to use, with no cost or commitment required from the user. The Nature Conservancy has assembled this information and is making it available to anyone via open website access. Coverage is being provided for most areas of significant wind speed in the U.S. Mapping will be updated as new scientific information becomes available. TNC is informing wind energy stakeholder organizations regarding the existence and benefits of this system. The use of the analysis system by wind energy deployment stakeholders can become a voice from the sustainable wind energy market.

Appraisal of the soaring bird sensitivity map tool for the Rift Valley/Red Sea Flyway based on local data from the Gabel El Zayt wind farm monitoring

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Abstract

The Soaring Bird Sensitivity Map (SBSM) tool has been designed under the framework of the BirdLife International-UNDP/GEF Migratory Soaring Birds Project which aims to integrate conservation of this group of birds into key sectors of countries within the Rift Valley/Red Sea Flyway. The main goal of this tool is to provide information and guidance to regional stakeholders and to support strategic planning of new developments, such as wind farms, with the purpose of minimizing negative impacts on migratory soaring birds.

The Gabal el Zayt Wind Farm is a 200 MW wind farm comprising 100 turbines whose blade's swept area extends from 20 m to 100 m above ground level. It encompasses an approximate area of 37 km2 and is located in a coastal portion of the Eastern Desert region in Egypt, near the western coast of the Red Sea and the Gulf of Suez. This area classified as being of Outstanding Sensitivity according to the SBSM, because the area is included in the Gabal el Zayt IBA, 31 species of soaring birds have been observed or are expected to occur and there is available information on the regular crossing of the area by satellite-tracked migratory soaring species.

Since spring 2016 a bird migration monitoring program and wind turbine temporary shut-down on demand operations was implemented in the Gabal el Zayt Wind Farm. The main objectives of these activities were to mitigate migratory soaring bird mortality at the wind farm and to obtain accurate estimates on the number of birds of each species as well as a thorough assessment of time and spatial patterns of migration in the area. Monitoring was conducted daily from 20 February to 20 May and involved 4-7 vantage points from where observers counted the birds, mapped their movements and informed about the need of shutting down turbines following pre-defined criteria.

We compared the monitoring data collected in 2016 and 2017 with that used to assess and classify the importance of the area by the SBSM tool. Although the overall number of species detected during field work was similar to that assigned to the area by the SBSM tool there

were some differences in the species list. Furthermore monitoring confirmed the occurrence of several species that were just assigned as potentially occurring in the area. The number of individuals belonging to species that provided satellite data to the SBSM tool observed during the monitoring was very high (e.g. White Stork *Ciconia ciconia* - over 120,000 individuals) and underlined the relative importance of the area within the context of the Rift Valley/Red Sea Flyway (near 30% of the flyway population in the case of the White Stork), exceeding what was estimated by the tool. The overall number of soaring birds reached nearly 400,000 strengthening the outstanding status of the area.

We discuss the importance of such monitoring effort to input accurate data to the SBSM tool and how real data from monitoring estimates may be used to calibrate more general data available for other places in the flyway and to re-access their SBSM classification. Moreover, we also discuss the importance of the application of radar and visual assisted turbine temporary shutdown of demand in targeted areas for wind energy production that hold simultaneously high importance for migratory soaring birds.

Can marine surveillance radars be used to adequately detect diurnal seabird movements at sea?

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Abstract

Nowadays there is a high demand for environmental impact studies connected to wind farms, and marine surveillance radar has repeatedly been exploited to undertake such studies. Their requirements include, among others, to quantify the volume of bird movements in time and space and to analyse how flying birds use the airspace within the area of a planned wind farm, by tracking single trajectories in two or three dimensions and allowing a detailed study of flight behaviour (flight speeds, flight altitude, distance to specific points). However, the limitations with respect to detecting and quantifying birds have often not been considered sufficiently and have led to a proliferation of radar studies with low quality.

In this study, we aimed to assess the relative detection capability of a commercial radar system (S-band surveillance radar; FURUNO FR-2137SBB, 30 kW, horizontal scanning antenna, located on a platform at 10 m above sea level), to describe the migration movements of seabirds across the north side of the Strait of Gibraltar (South Spain). For this purpose, radar and visual surveys were simultaneously carried out in three sequences of ten minutes during hourly censuses at Tarifa Island, SW Spain. Every seabird flock detected by the visual observer was communicated to the radar operator, who tried to detect this flock on the radar screen. When the radar operator was able to detect the echo of the target, it was registered as a 'detected target'; otherwise, it was registered as a 'non detected target'. In this manner, the number of visually detected flocks of seabirds is compared with the proportion of those detected by the radar, in order to evaluate the radar detection. Additionally, generalized regression models were employed to analyse the factors influencing seabird detection, in order to test the following hypothesis: (1) detection varies according to species and flock size; (2) the

relative capacity of the radar to recover visually detected birds will decrease with distance; (3) the relative detection capacity of the radar will decrease with increasing wind speed generating sea clutter.

Only 35.3% of the visually observed birds could be acquired by the radar. The main factor limiting the detection capacity of marine radars is sea clutter related to wind strength. With wind speeds above force 5 of the Beaufort scale the capacity of the radar to take up visually detected targets dropped close to zero. The different seabird species detected and identified visually could be acquired by the radar in similar proportions, but large flocks were more easily registered by the radar than small flocks. Moreover, within the range birds were detected in our study, the proportion of birds taken over by the radar from the visual observer was independent of distance.

Concerning implications for the application of radar for off-shore windfarm studies, we provide field evidences that commercially available marine radars may suffer important limitations in terms of seabird detection. Thus, at date, parallel visual observations constitute the most feasible and reliable method to complement radar surveys. The limitations in the quantification of seabird passage do, however, not devaluate the usefulness and applicability of radar technology with respect to information on flight directions, flight speed and spatial distribution of migratory pathways.

Spatially explicit tools for the assessment of potential impacts of marine renewables on breeding seabirds

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Abstract

In order to properly assess the potential negative impacts of offshore renewable energy developments upon seabirds, it is necessary to both estimate the effects of a proposed project, and to assign these effects to the appropriate reference population or colony. This presentation briefly describes the methods and results from two research projects commissioned by the Scottish Government to fill critical knowledge gaps in research in this field that underpins the planning and assessment process, and the spatial tools that resulted. The first project estimates the likelihood that birds at a given at-sea location during the breeding season originate from each candidate colony. Whilst at-sea bird surveys can estimate the number of birds potentially affected by a proposed development, they provide no information on the colony of origin for those individuals. Historically, such 'apportioning' has been carried out using a simple calculation based on the distance to each colony and the size of each colony, assuming that foraging ranges from adjacent colonies overlap, despite evidence that this is often not the case. A spatially explicit tool based on an apportioning model that utilises existing GPS tracking and at-sea survey data was developed for UK waters that apportions both breeding and non-breeding birds of three key UK breeding seabird species (common guillemot, black-legged kittiwake and razorbill). The second project focuses on the displacement and barrier effects that may result from marine renewables on breeding seabirds that commute between breeding and foraging sites. For a given 'wind farm' location, size and orientation, the model estimates the effects on survival and productivity of individuals that are displaced or for which the wind farm acts as a barrier to movement, in five UK breeding seabirds (common guillemot, razorbill, Atlantic puffin, black-legged kittiwake and northern gannet). The presentation will

finally describe how these publically available spatially explicit tools can be applied in marine planning and impact assessments.

Keeping an eye on offshore wind and wildlife: The world's largest digital aerial survey off the Long Island coast

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Abstract

Aerial digital surveying techniques using aircraft flying at significantly higher and safer altitudes than observer-based aerial surveys have become a key tool in environmental impact assessment (EIA) of offshore windfarms worldwide. In preparation for offshore wind energy development, the New York State Energy and Research Development Authority (NYSERDA) has initiated a large-scale offshore high-resolution aerial survey of marine wildlife. We are carrying out 3 years of baseline surveys (2016-2019) to assess the entire New York Offshore Planning Area (OPA) with emphasis on the Wind Energy Area (WEA).

The surveys use ultra-high-resolution aerial digital imagery captured with the purpose-assembled camera system "Shearwater III" at 1.5 cm ground sampling distance (GSD) from a Piper Aztec twin engine aircraft flying at 1,360 ft. The nearshore area is surveyed along transects parallel to the shoreline and the offshore area is surveyed along transects perpendicular to the shoreline and consequently to the bathymetry, providing optimal orientation for expected clines in the distribution of target species.

The WEA is surveyed using a grid design, in which the area is covered equidistantly in all orientations. The resulting georeferenced positive signals are used to assess the distribution and abundance by birds, marine mammals, turtles, and fish. The data collected in the surveys of the OPA and WEA are regularly uploaded to the internet domain ReMOTe (http://www.remote.normandeau.com/public_data.php).

Our analysts and taxon-specific experts log into ReMOTe to access the raw data, identify species, and interpret results. As data review progresses, survey results are publicly available on ReMOTe in near-real time. This comprehensive baseline study using an innovative survey technique will facilitate a more efficient planning of energy production offshore by providing the necessary information to meet regulatory requirements for environmental review of WEAs.

2.2.6 *Parallel Session 12: Planning & Policy II*

Experiences gained from delivery of offshore wind energy in the UK that could inform the environmental assessment of Portuguese projects

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Abstract

Offshore wind consenting and development is developing within Portuguese waters, but an understanding of likely impacts has yet to be established to inform the environmental impact assessment (EIA) process. The UK has a more mature offshore wind industry, and as a consequence EIA practitioners and stakeholders have developed a greater understanding of impacts arising from the construction and operation of the infrastructure. In particular, the process has matured to provide confidence that some routes to impact will not cause a significant effect and thus can be scoped out of the environmental impact statement (EIS). In addition, impact methodologies have been developed to enable assessment of impacts at a population level. This latter development has proved particularly important within the Habitat Regulation Assessments necessary under the Natura 2000 legislation. There is great interest in identifying the lessons learned from UK to inform the consenting process in PT.

Critical review of the consenting procedures for EIA of offshore wind energy projects in PT were compared to UK practices, including the analysis of guidance, public participation, stakeholder's engagement and EIA requirements. Interviews with authorities, experts and developers were conducted to identify different expectations.

Scoping is a key component of the EIA process in both PT and the UK. It is undertaken in the early stage of the project planning/design to agree the environmental receptors present in the proposed area that should be considered further during the EIA process. In the UK, the scoping process also includes agreement of methodologies of site specific surveys that should be utilised to fill knowledge and data gaps. This reduces the potential for expensive surveys that stakeholders consider inadequate to address the requirements of the EIA process.

PT determining authorities potentially see offshore energy projects as having numerous unquantified or uncertain impacts. Uncertainty within impact assessments usually results in

the adoption of the precautionary principle, and thus conservative assessment outcomes and over-prediction of impacts. Within the UK, post construction monitoring is helping to reduce some of the conservatism that has arisen within assessment methodologies as a result of these uncertainties. The survey data has provided stakeholders with the confidence to allow developers to scope out potential impacts that are unlikely to result in significant effects in UK waters. Examples will be provided and discussed.

Lessons from development of survey plans within UK waters also provide evidence that there is little to be learned by repeating baseline surveys as post-construction monitoring campaigns. Baseline surveys provide general information on the site specific use of the site. They are generally not sufficient to allow the detection of significant change in a population density of a species (i.e. the actual impact) following the introduction of a wind farm into the environment. Lesson learnt from the UK show that post consent monitoring of impacts should to be questions driven, and robustly designed to be effective at answering such questions.

Using the lesson learnt from the UK will probably mean that potential impacts will continue to be conservatively assessed. But it may help to limit some of the precautionary principles to reflect realistic scenarios, and limit EIAs to potentially significant effects.

Considerations for upscaling individual effects of wind energy development towards population-level impacts on wildlife

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Abstract

The expansion of wind energy poses challenges to policy- and decision-makers owing to the conflicts associated with impacts of existing and planned projects on wildlife and associated difficulties of prediction where impacts are subject to considerable uncertainty. Many post-construction studies have demonstrated adverse effects on individuals of various bird and bat species, either in the form of collision-induced mortality or of behavioral or physiological changes reducing the fitness of those individuals exposed to wind energy facilities. Yet there is an urgent need to upscale individual effects to population impacts, which is generally the true value of interest from a conservation point of view. This presentation identifies methodological issues associated when moving from individual effects to population impacts in the context of wind energy, discussing good practice and the challenges for policy and decision makers tasked with simultaneously reducing conflict and improving evidence for future decision-making. By reviewing recent case studies, we identify distinct methodological approaches to predict impacts and we describe the various choices of study designs and metrics available to detect significant changes at the population level. We then discuss ways to derive impact thresholds relevant for decision-making. We argue that although even robust monitoring schemes and sophisticated modelling techniques will inevitably be unable to describe the whole complexity of wind and wildlife interaction and the natural variability of animal populations, they will provide an improved understanding of the response of wildlife to wind energy and better informed policies to support risk-based decision-making. Policies that support the use of adaptive management, which aims at reducing scientific uncertainty while managing a given natural resource, will promote the adoption of assessments at the population level in order to adequately balance the development of wind energy with the persistence of wildlife populations.

Introducing BirdLife International's Soaring Bird Sensitivity Mapping Tool for the Mediterranean

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Abstract

The best way to ensure that wind farms do not have a detrimental impact on bird populations is to site them away from sensitive areas. However, by the time that an Environmental Impact Assessment (EIA) has been concluded, plans for a wind farm are often well advanced. Developers then face a stark choice between persevering with a project that may ultimately be environmentally unsound or abandoning the location and starting over, a financially costly option. It is therefore essential that developers, funders and planning authorities undertake biodiversity evaluation 'upstream' whilst preliminary site selection is still underway.

To this end, BirdLife International, working with a network of regional partners, developed the Soaring Bird Sensitivity Mapping Tool, an online tool which allows users to investigate the potential for conflict between soaring bird species and wind farms. The first iteration of the tool, launched at the 3rd Conference on Wind energy and Wildlife impacts (CWW 2015), covered the Middle East and Northeast Africa. Since its launch, the tool has become an important instrument for ensuring the environmentally sound expansion of wind energy in the region. Its use is now integrated into the safeguarding procedures and protocols of a number of international financial institution (IFI) and several government agencies and conservation NGOs have developed their own national planning systems bas'd on the tool's methodology.

Following this initial success, and thanks to support from the MAVA foundation, the tool has been expanded to cover the Mediterranean region, namely countries in North Africa and Southern Europe including the Balkan Peninsula and Turkey. Working with BirdLife's national Partners across the region, data was collated on 56 species of soaring bird from the following families' Pandionidae (Osprey), Accipitridae (Hawks, Eagles), Falconidae (Falcons), Gruidae (Cranes), Ciconiidae (Storks), Threskiornithidae (Ibises, Spoonbills) and Pelecanidae (Pelicans). Soaring birds, especially raptors, are known to be especially vulnerable to collision with wind turbines. They are often large-bodied, have limited manoeuvrability and have flight behaviours that heighten collision risk. In addition, they are typically long-lived species that

take several years to reach maturity and have high adult survival rates. There is, therefore, considerable potential for the mortality caused through wind farm collisions to cause population level declines.

The tool contains thousands of georeferenced records of soaring birds from across the region. The principal source of these is BirdLife's Important Bird and Biodiversity Areas (IBAs) database. Additional soaring bird records have also been collated from a wide range of literature sources and data archives. The tool also contains satellite tracking data and species' range maps, as well as spatial data on protected areas and relevant topography to provide additional contextual information. Most significantly, a simple, explicit formula is used to assign sensitivity categories, thus allowing for an objective assessment and comparison of prospective locations based on their potential to be sensitive areas for soaring birds.

Further geographic and taxonomic expansion is anticipated such that tool should increasingly be recognised as an essential resource for wind farm spatial planning globally.

Managing Wind Farms - What is the Role of Adaptive Management?

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Abstract

Both land-based and offshore wind energy continue to face controversy over potential threats to populations of birds and bats. Tools are needed that can assist the wind industry bridge the gap between the scale of population effects and the permitting decisions that are made at individual wind farms.

Adaptive management (AM) is a learning-based management approach that is used to reduce scientific uncertainty, and has been applied to many types of development including filling of wetlands and various forms of renewable energy. AM has been identified as a tool that could advance the wind energy industry, although its application in practice has been limited. AM has primarily been actively implemented in the United States, while other nations have applied some of the principles of AM. Many wind energy projects use the mitigation hierarchy or the precautionary principle to guide development, both of which focus on mitigating or avoiding project-related risks or impacts. Overall, AM allows wind energy projects to adapt monitoring and mitigation over time, leading to improved decision-making. The WREN nations have developed a white paper on AM that explores how AM principles are used by the wind energy industry in several nations, and identifies ways the process and its implementation may be improved.

The international collaboration WREN (Working Together to Resolve Environmental Effects of Wind Energy) under the IEA Wind Committee identified the application of adaptive management principles and practices as an important aspect for improving planning, monitoring, and management of wind farms in the United States and internationally. WREN has produced a white paper on adaptive management that suggests a common definition and framework for AM, based on the U.S. Department of the Interior's AM definition and guidance. Our objective is to reduce uncertainty, share research and monitoring results, and disseminate that knowledge to assist in responsible development of land-based and offshore wind energy internationally. This presentation will discuss results of the white paper.

Guidelines for assessment of wind farms impact on large carnivores in Croatia

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Abstract

The Dinaric mountain range, due to its wind potential is the preferred area for wind farm development in Croatia, but in the same time it represents a valuable habitat for large carnivores (wolf, bear and lynx). To ensure adequate assessment of wind farm impacts on large carnivores, a 'Manual for assessment of wind farms impact on large carnivores' was developed. The manual can be used for all environmental and nature related assessment procedures (Strategic environmental assessment (SEA), environmental impact assessment (EIA), and Appropriateness assessment (AA). Since the major threat to large carnivore survival is habitat fragmentation and habitat loss, the strategy for reduction and avoidance of individual and cumulative impacts was developed. The Guidelines propose an assessment methodology based on the sensitivity maps (probabilistic grids), which were created by modelling in GIS (Mahalanobis distance), using data on large carnivore occurrences relative to habitat characteristics. The sensitivity maps indicated the importance of certain area for each species of large carnivores through defined nine classes of habitat sensitivity at the resolution of 250x250m, where class nine represented the best available habitat, while class one represented unsuitable habitat). Habitat loss due to wind farms development was calculated as a circle with radius of one km around each wind turbine, when general carnivore needs were considered, and as two km circle, when the impacts on their reproduction areas had to be assessed. The threshold (in %) of further loss of each class of habitat was set, also with calculated absolute limits (in square kilometers) for the entire area of large carnivores permanent and occasional occurrence in Croatia. The calculated values need to be taken into account while conducting strategic environmental assessments and cannot exceeded cumulative threshold on the national level. The acceptable future loss of habitat was set at maximum of 1% for the class 9 habitat, 2% for the class 8 and 3% for the class 7 of habitat respectively. On the other end of the scale, the acceptable loss of class one habitat was set to 100%. Loss of habitat needs to be calculated cumulatively for all planned interventions for the county where planned project

will be situated (in EIA procedures) or as the % loss of the Natura 2000 areas, during AA assessment.

2.3 Day 3 - September 8, 2017

2.3.1 *Parallel Session 13: Population impact modelling*

Using population models and potential biological removal to estimate the impacts of wind energy on United States raptor populations

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Abstract

Understanding the cumulative effects of fatalities from wind energy on the status of wildlife populations is a top research and conservation priority. We used 3 approaches to estimate impacts of wind energy on populations of 14 raptor species across the continental United States (US). We first used population matrix models with parameter estimates derived from the literature (matrix approach). Then we used observed population trends from the US breeding bird survey (BBS) from 1970 to 1990 (i.e., prior to installation of large amounts of wind energy across the US) (observed lambda approach). For the third approach, we estimated potential biological removal and compared it to estimates of annual fatalities from wind energy (PBR approach). We compared these three approaches because of uncertainty about how turbine collision mortality should be modelled (i.e., the degree to which mortality is additive or compensatory). The matrix and observed lambda approaches treat mortality as additive, while the PBR approach treats it as largely compensatory. Comparing the two demographic modeling approaches (matrix vs observed lambda) illustrates a cautionary tale. The baseline population growth rates differed by 5 to 26% between the matrix and observed lambda approaches, and for some species, the approaches indicated opposite population trends. Many raptors show regional variation in population dynamics across the US; while the observed lambda approach utilized BBS data from across these regions, the literature-based estimates of the observed lambda approach did not. The lack of geographic coverage and limited study duration of the literature-derived estimates may be responsible for some of the differences between BBS and literature-based population trends. In addition, BBS may not generate accurate estimates of

population trend for some of the raptors because it samples a small portion of their breeding range. The observed lambda and PBR approaches resulted in positively correlated predictions of impacts from collision fatality. Furthermore, species varied in their responses to fatalities, with some species projected to decline under forecasts of future wind energy development. In other cases, species already in decline would decline even faster given increased collision fatalities. The level of estimated of fatality and life history characteristics influenced species responses to wind energy. Significant bias may exist in species-specific estimates of wind energy fatalities, so results from any approach that requires such data, including ours, should be used with caution.

How to assess whether impacts from offshore wind farms cause unacceptably large declines in protected marine bird populations?

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Abstract

During the Environmental Impact Assessment process, decision makers and their advisors need to assess whether predicted impacts from a planned offshore renewables development will bring about unacceptably large declines in protected marine bird populations. This is both a population biology and a policy question. For example, population modelling can assist with predicting how future population size might change as a consequence of the predicted impacts from the development. However, whether this change is deemed acceptable by decision makers will depend on the particular management objectives for that protected population, e.g. Conservation Objectives for Natura 2000 sites in Europe. During impact assessments undertaken in Europe, management tools such as Potential Biological Removal have been used to identify a threshold of additional mortality that a population can withstand, while still meeting management objectives. These tools are appealing because they appear to address both population biology and policy questions within a single tool, making management decisions simpler. However, these tools make implicit assumptions about the focal population, such as population trend and the presence and form of density-dependent regulation. These assumptions are rarely explicitly considered during the impact assessment process and are often not met in reality. We used Leslie matrix population models to explore population responses to various levels of additional mortality, in a range of scenarios in which population regulation and trend were varied. In this presentation, we illustrate the consequences of not meeting assumptions implicit within management tools and discuss the management implications of this. These include wrongly concluding that, when predicted impacts are smaller than thresholds identified by management tools, management objectives for that population will be met. This could potentially lead to inappropriate consenting decisions. Consequently, we recommend using a Population Viability Analysis (PVA) approach to quantify the relative

predicted changes to future population size and growth rate, attributable to impacts from a planned development. The acceptability of such population changes can then be explicitly considered with reference to management objectives for that population. We suggest approaches for using PVA on data-deficient marine bird populations and summarise results from a review of demographic rates and forms of density-dependent regulation in European marine bird populations.

Quantifying the vulnerability of seabird populations to potential anthropogenic mortality

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Abstract

As the offshore wind industry seeks to expand, assessment of wildlife population level impacts requires continued reduction in uncertainty and refinement of realism in theoretical approaches. Population Viability Analysis (PVA) is a favoured tool used to investigate population vulnerability but conventional PVA often fails to quantify the influence of demographic stochasticity, environmental stochasticity, estimation uncertainty and density dependence.

Using Bayesian state-space modeling fitted to population time series from three seabird species with diverse life histories, we first quantified the extent to which their dynamics are driven by environmental stochasticity and density dependence. The posteriors of our models were used to define plausible ranges for the strength of intrinsic and extrinsic regulation for each study species.

The widespread but *ad-hoc* assessment tool Potential Biological Removal (PBR), applied along a sliding scale of precaution, was used to determine different strategies for acceptable anthropogenic mortality on each of the three study species. Using our fitted state-space models, we conducted a population viability analysis (PVA) applying our PBR mortality scenarios across the entire space of credible scenarios for intrinsic and extrinsic population regulation. Results of the impact of PBR highlighted vulnerability of decline on populations under regulation of higher density strength and higher environmental variation. Declines were found to a greater magnitude under closed population scenario modelling, comparative to those populations that were re-seeded, preventing permanent extinction.

Policy Implications: Identifying vulnerability of populations under different regulation may be key in mitigating against wildlife extinctions, detecting those populations and conditions that exacerbate risk. Here, we detail the impact of additional mortality to three life histories under different regulation. We evaluate the patterns of risk in the context of models assumption (closed or re-seeded) and comment on the appropriateness of PBR as a tool for risk assessment in its current application to wildlife populations.

Dealing with uncertainties in bird and bat population impact assessments for individually planned wind farms

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Abstract

Impact assessments for planned land-based wind farms near important bird or bat areas often require a quantitative approach for certain species, including the significance of the impact at population level. However, the applied thresholds for a significant impact contain many uncertainties and often give rise to discussions.

A widely applied global threshold for assessing the significance of a mortality impact from human activities is 1% of the normal annual mortality in a bird population. In many cases this is calculated from current survival rates reported in the literature. For abundant bird species with a favourable conservation status, the threshold may go up to 5% following an in-depth scientific analysis. These thresholds were originally defined by the European Commission for assessing hunting levels, but they can also be used for wind turbines or other current human activities. Similar thresholds can probably be applied for the amount of birds that experience significant disturbance.

Recently, the Council of State in the Netherlands declared that the 1% threshold for birds can also be applied for bats. But in most cases, there is insufficient information on the population sizes of bats. The possible number of bat fatalities in planned wind farms is also more difficult to estimate than for birds.

In a global approach the proposed thresholds can be used, but in reality many local factors can play a role in the complex species population dynamics. Therefore, more complex population modelling is recommended. However, in most cases this is not possible for assessments of individual small wind farms.

Another problem lies in the scope of the assessed population. In an optimal scenario, the assessed population is at a biogeographic scale. But to minimize cumulative effects, a country or regional scale is preferred. However, even at this scale, in individual project assessments it is almost impossible to take into account the cumulative effects from all wind farms and other relevant human activities. Moreover, to determine the possible significant effects on the

integrity of a Natura 2000 site (or network of sites), the population needs to be assessed on that smaller scale.

Therefore, in individual project assessments in Flanders (northern region of Belgium), at this time, we propose to apply the global 1% and 5% thresholds for bird populations at a more local or subregional scale. For example, in case of wintering ducks, the subregional scale consists of all ducks in the areas that are ecologically connected throughout the winter season. An assessment at a larger scale is possible when cumulative effects can be calculated sufficiently. For bats, a more qualitative evaluation is only possible for now. We also propose to build a model on a regional scale to regularly assess the current cumulative impact of all wind farms in Flanders, preferably based on monitoring results of operational wind farms. The output of the model could be used to improve the more local or subregional thresholds.

How should we assess the population level consequences of impacts from offshore wind farms on seabirds?

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Abstract

Understanding how impacts on individuals affect a population as a whole is a key challenge for ecologists involved in the planning process. However, quantifying impacts, for example increased mortality or reduced productivity, and scaling them up to the population level is challenging, and conclusions may be influenced by uncertainty surrounding the modelling process and/or population status. We describe a framework with which to assess population level-effects associated with developments. We investigate the extent to which decisions may be driven by our understanding of the population concerned. We found that conclusions could be influenced by our understanding of adult survival rate and, in some cases the estimates of uncertainty surrounding those rates. We also found that pre-impact population trend may influence conclusions, with impacts more likely to be identified as unacceptable in stable, as opposed to increasing or declining, populations.

Incorporating environmental stochasticity into models increased the magnitude of predicted population-level effects, whilst (compensatory) density dependence reduced the magnitude. Using a matched runs approach for stochastic models resulted in reduced uncertainty surrounding estimates of population-level effects. We conclude that a comparison of impacted and unimpacted populations is likely to be the most appropriate criteria on which to base decisions about whether any impacts can be considered acceptable. However, these decisions need to be transparent and made in the context of the population concerned; they may reflect wider societal considerations, but must rely on a firm understanding of underlying biological processes.

2.3.2 *Parallel Session 14: Trends, tools and technologies II*

Evaluation of the DTbird-system as a mitigation measure for Swedish avifauna

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Abstract

Continued investments in renewable energy in Europe - where wind power plays an important part - will accentuate the need to further reduce the impact of wind power on the avifauna. Solutions to mitigate the risk of collision for birds includes the ability to stop the WTG before the birds fly across the rotor swept area and to induce an avoidance reaction in the proximity of the WTG.

In 2015 a pilot project was set up in order to 1) install and demonstrate a DTBird system in Sweden, and 2) evaluate the usefulness of the DTBird system and how the sound emission of DTBird affects the risk of collision between birds and the wind turbine. The DTBird system was installed on a Vestas 850 kW turbine with a tower height of 74 meters and a rotor diameter of 52 meters. Data were collected during July to September 2015, which is, during part of the breeding and migration period of birds in Sweden. The evaluation methodology consisted of the activation/deactivation of sound emission on a weekly basis, and the comparison of collision risk variables determined from video records.

The pilot study analyzed how effective the DTBird system has been to ward off birds from the wind turbine and thus the area with high risk of collision, how far the emitted warning and discouraging signals can be heard by people living nearby, and if the sounds emitted by the DTBird system affects the density of birds nearby the wind turbine. Registration has also included duration of sound emission, as well as stop signals, and an estimate of the production loss that shutdown of the wind turbine would have entailed.

The pilot study indicates the following results. The recorded flight time in the high collision risk zone with sounds activated decreased by 60% for birds in general and by 87% for groups raptors and cranes combined. Of the recorded bird flights on collision route with the WTG evasive actions that made the bird fly away from the WTG was clearly seen in 88% of the

cases. The number of registered bird flights more than 100 meters from the WTG did not decrease during the pilot study.

The distribution of the warning signal in proximity to the wind turbine is heavily influenced by the topography around the installation site. The limit of 40dBA reach less than 750 meters from the sound source in most topographic scenarios. This fits well with the experience of local residents' experiences of sound for more than a year.

The study indicates that automatic emission of warning and discouraging sounds has reduced the risk of bird collisions with the WTG.

Thermal imaging, acoustic trajectography and carcass search

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Abstract

The impact of wind parks on bats has been traditionally evaluated simply by looking for carcasses underneath the wind turbines. This approach does offer certain advantages. For example, examination of the carcasses yields information on their species, age, sex and possibly even their origin (isotopes). However, it only provides an indirect evaluation of mortality rates, while masking a significant amount of other information.

In order to establish a more informative tracking method that also takes operators' financial constraints into consideration, we have combined three tracking methods to be employed simultaneously: 1) searching for carcasses on the ground; 2) thermal imaging; and 3) acoustic trajectography. This hybrid method was used over a three-month period during the summer of 2015 on eight wind turbines spread out over three wind parks in Wallonia (Belgium).

This approach offers a rigorous evaluation of mortality rates, while also tracking the number of flybys that occur with no interaction between bat and machine. It has also furnished us with data on the precise conditions under which mortality has been observed (date, time, wind speed, temperature) and on the wind turbines' power of attraction, as well as remarkable video footage of barotrauma and collisions.

Thus, the infrared cameras appear to be a particularly informative tool that might offer an attractive alternative to conventional mortality tracking methods. They enable consistent long-term tracking, easy comparisons between wind parks, evaluation of the effectiveness of measures and regulations, and possibly even adjustments in real time. The most recent developments in the area will be presented in order to evaluate opportunities for optimizing the cost-effectiveness of these methods.

Life Cycle Assessment as a tool for assessing impacts of wind energy production on wildlife

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Abstract

Studies on impacts of wind energy production on biodiversity show that wildlife, especially bats and birds, is adversely affected through collision, disturbance and habitat alterations. Even if these effects may be relatively low in comparison to other energy sources, the cumulative impacts due to the installation of projected wind farms may significantly impact populations. Wind power might also come as an additional impact to already existing environmental impacts, contributing critically to the increase of impacts upon specific species and populations. Modeling these impacts across the life cycle of one or several wind farms is therefore important to balance the trade-offs between mitigating climate change and biodiversity conservation. However, most quantitative impact assessment methods are limited in terms of species, spatial or impact coverage. Furthermore, most of these models report impacts in absolute numbers of individuals affected and do not deliver a metric relative to the electricity produced by the assessed wind turbine or farm. This is a relevant relative comparison to weight the environmental performance of different wind energy systems or different other energy production systems against each other.

One tool that allows for such cross-comparisons is life cycle assessment (LCA). LCA is a tool that aims at capturing all resource uses, emissions and environmental impacts over the whole life cycle of a product (e.g. a wind turbine), thereby covering a large number of impacts on ecosystems, such as land stress, climate change, eutrophication or ecotoxicity. However, current LCA models do not cover impacts from wind energy on biodiversity. Therefore, we aim to demonstrate possible ways for achieving this.

We reviewed the suitability of existing quantitative models to predict the life-cycle impacts of wind energy on wildlife, with special focus on birds and bats. Regarding their vulnerability to wind energy development, bird and bat species can be grouped by flight behavior and morphological characteristics. Habitat alterations and displacement effects can be based on species distribution and habitat suitability models, often including flight initiation distances

for different species. Modelling collision effects is more complex, but can also be addressed via species distribution models in combination with other approaches (e.g., collision risk models). These models can be used as a starting point for modeling biodiversity impacts in LCA. Due to data availability, we developed a regionally specific method for Norway. However, given the differences between countries or regions in terms of species composition, environmental variables and technology used, we developed our model with plans of future upscaling to a global level. Our model shows as a preliminary result a map with the impacts from wind energy production on birds and bats in Norway, predicting damage for every kWh produced.

This LCA approach enables comprehensive comparisons of various siting options of wind farms and cumulative impact assessments on biodiversity, while taking the vulnerability of different species groups into account. The addition of this biodiversity impacts within an LCA framework will provide stakeholders with more robust indicators for better decision-making, both in the wind energy sector and other industrial sectors attempting to reduce environmental impacts.

The Chronological Evolution of Wind and Wildlife in the United States

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Abstract

Our understanding of wind/wildlife interactions in the United States has evolved over the last 40 years. This presentation will present the chronology of the wind industries evolution of wind/wildlife interactions from the 1980's to the present time. We will show the progression from 1) recognizing a potential problem, 2) analyzing the problem in the context of individuals (i.e., number of bird or bat fatalities), 3) putting the problem in a population context, and 4) developing avoidance and minimization options.

Industrial scale wind developed in the United States started in the Altamont Pass Wind Resource Area in California when wind/wildlife interactions had not been documented. Based on observations of raptor fatalities, systematic mortality monitoring began. This monitoring initially increased both our understanding of the importance of siting wind farms with respect to topography, but also resulted in the wind industry's understand of potential impacts evolving from raptors to songbirds to bats. Part of this evolution has occurred as attention has been focused on fatality estimation through the addition of mathematically advanced searcher efficiency, carcass persistence, area corrections.

Over the years, as studies were conducted across the country, taxonomic and regional patterns emerged in bird and bat fatalities. For small birds, fatality rates range from 1.4 to 4.0 birds/MW/year with limited regional variability. Pre-construction surveys do not provide good predictions of post-construction fatalities, likely because the taxonomic group with the highest fatalities found in nocturnal migrant passerines and the lowest fatalities among water birds. Raptors are a species of concern and technologies have been developed to both detect and deter raptors. For bats, fatality rates range from 1.4 to 41.2 bats/MW/year with the highest fatality rates in the forested, eastern region of the country.

Pre-construction surveys also do not provide good predictions of post-construction fatalities due to attraction of the bats to the wind facilities, a pattern for which many hypothesizes have been postulated. The taxonomic group with the highest fatality rates is the migratory, tree-roosting bats during the late-summer/fall periods. In response to bat fatality rates, an

assortment of bat deterrents have been or are currently being tested, including a variety of alternations of cut-in speeds (with or without feathering), acoustic deterrents, and reflective paints.

As impacts to individuals were documented, population impacts have been evaluated. For songbirds, no species-specific concentrations of fatalities occur and assessments have concluded that impacts to songbird populations are unlikely. Raptor population analyses are currently underway and results of these will be presented. Unlike birds, bat population size and changes over time are limited to species that roost in large concentrations in caves or other easily-surveyed areas. Recent population genetics papers may provide the first step to evaluating bat population-level impacts in the US.

In addition to fatality estimates, our understanding of wildlife behavior has also evolved over time. This evolution includes the potential of avoidance behavior, either local or larger scale, of grassland birds, grouse, and whooping cranes. Conversely, bats appear to be attracted to turbines, and studies are currently evaluating the proposed hypotheses.

Integration of wildlife detection and deterrent systems

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Abstract

The technology for wild life detection and deterrent is expected to develop rapidly so turbine manufacturers and project developers need to focus on flexibility in order to be prepared to adopt new technologies that may develop over the life time of a new project.

The integration of detection and deterrent shall have focus on data security as some of these systems will be able to impact the grid indirectly and could be used to destabilize the grid if not designed correctly or if not integrated appropriately. As the penetration of renewable increases this becomes more of a concern, and by incorporating a grid risk assessment early on in the design phase of any detection or deterrent system, the cost of adopting best practices for data security may be reduced and sure the risk to the grid stability will be minimized. Specifically solution to be integrated into the wind power plant SCADA systems needs to address user account management, encryption of critical configurations, authentication, and end point management.

From a turbine equipment manufacturer perspective facing multiple technologies aiming to achieve to a large degree the same goal of either detecting or deterring wild life in the airspace around the wind power plant, developing a uniform data interface can provide some integration benefits, and maybe such data tags or commands should even be considered under the IEC 61400-25 standard as a way to further ensure interoperability between multiple vendors of both wind turbines and detection deterrent vendors. It is very likely that new technology will evolve and need to be integrated over the life time of wind power plants, so some level of consistency or alignment may be to every stakeholders benefit.

From a regulatory perspective there needs to be a focus on the desired outcome and not a focus on the actual solution or how the developer chooses to solve the problem. This will provide the most open field for creative solution to enter the market. If the regulatory rules stipulate that a technology needs to be certified or approved to be applied then the operator may not have the option of installing multiple systems that combined for the given locations can achieve the desired mortality improvement. If the target is a predefined incidental take,

then it should be op to the operator to find the best and most cost effective mix of detection, informed curtailment or deterrent to achieve the desired target regardless of how well the individual system deployed perform as long as the combined integrated system meets the target.

The success of all detection and deterrent system depends on a good understanding of the species involved, and this points to the need for details studies of such species and close collaboration between the wind turbine manufacturers, wind power plant developers, regulators and environmental community in order to share knowledge in this area as soon as new knowledge becomes available in order to give the developers as many tools to work with as absolutely possible to reduce the negative environmental impact of the transition to a noncarbon based electrical system.

2.3.3 *Parallel Session 15: Ecosystems & Holistic approaches*

Ecosystem approaches in ecological impact assessment: lessons learned from wind energy development on peatland in Scotland

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Abstract

Scotland has one of the best wind resources in Western Europe, and wind energy represents over 70% of installed renewable capacity in 2016. This dynamic is driven by the ambitious targets of the Climate Change (Scotland) Act of 2009 which requires 100% of electricity demand to be delivered from renewable sources by 2020. The majority of wind farms in Scotland are proposed on peatlands as these are usually areas with favourable wind characteristics, are generally less economically-productive, and are often located away from human settlements. The construction of wind farms on active peatlands leads to habitat loss and degradation, release of carbon stored in the peat, and long-term alteration of ecosystem function.

Peatlands are complex ecosystems built up of an interconnected mosaic of individual units and subunits with characteristic morphology and topography. If one or more components of the complex are hydrologically disrupted, the stability of extensive parts of the complex as a whole can be lost. By a domino effect, hydrological alterations can spread far from the initial impact. Taking this hydrological interconnectedness into account is essential to adequately assess and address the impacts of wind energy projects on peatland.

In practice, the Environmental Impact Assessment (EIA) process does not often incorporate the concepts of ecosystem function, health, thresholds and limits. Instead, impact assessments concentrate separately on species, habitat quality and various other features depending on jurisdictions. This contrasts with ecosystem management approaches and tools that are increasingly used in fisheries, forestry and conservation. There is now a broad consensus that biodiversity goals are best achieved by targeting populations and communities of interacting species, within ecological systems, rather than a single or small sets of species considered in isolation.

We reviewed 21 environmental statements of >50 MW wind farms approved by the Scottish Government to determine if and how an ecosystem approach is used in these projects, and explore what an ecosystem approach would look like for wind farm development on peatland in general, and in Scotland in particular. This review was based on a review package developed against recent EIA guidance and best practice for mitigating wind energy impacts.

We found that most practitioners, when assessing impacts on peatland, focus on individual vegetation types (habitats), thereby overlooking the structure of the impacted ecosystem, and associated biodiversity features. Clearly, simple distance buffers, which are often the default approach as in the case of wind energy projects in Scotland, are not appropriate in most circumstances. Shifting the focus to the whole hydrologically linked system would lead to better decisions.

Wind energy development on peatland offers a good illustration of the usefulness of an ecosystem approach to impact assessment. Such approaches are possible wherever meaningful functional management units can be defined, including in marine environments. Similar questions are raised in the definition of 'discrete management units' in applying the Performance Standards of the International Finance Corporation to projects affecting threatened species (and habitats) or the continued ecological functionality of breeding sites or resting places required under the EU Habitats Directive.

A synthesis of effects and impacts of onshore wind farms upon wildlife: from plants and invertebrates to reptiles, terrestrial mammals, bats and birds

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Abstract

The first volume of Wildlife & Wind Farms: conflicts and solutions has attempted to compile all known and potential effects upon wildlife at a range of trophic levels from flora to invertebrates, fish, amphibians and reptiles, terrestrial mammals, bats and birds. A total of 40 expert authors contributed detailed information in specific chapters. Here, I present a unifying synthesis of the effects and impacts described, whilst also incorporating information from recent studies and grey literature. Key points are illustrated with the permission of the original authors. It is striking that no peer-reviewed studies were available from some of the World's major producers of wind energy. The level of available information also varied widely across taxonomic groups. As expected, the collision of birds and bats and the displacement of birds have been widely studied, particularly in Europe and North America. Displacement has been demonstrated for risk-averse bird species, although the mechanisms behind disturbance typically remain unclear. In this context, an Increase in human presence may be important for some large mammals. The consequences of displacement upon individual fitness generally remain unmeasured. In contrast, a small number of longer-term intensive studies of collision mortality of raptors have demonstrated impacts upon local populations with possible consequences at larger scales. Whilst the scale of bat collisions appears considerable, judging impacts has been hampered by a lack of knowledge of population demography and dynamics. Cumulative effects upon any taxon, particularly migratory species, have barely begun to be addressed. Until further research fills knowledge gaps, the uncertainty of impacts should be embraced by avoiding conflict in the first place through careful selection of sites and turbine locations. The combination of the typical scale of habitat loss and modification during construction activity, the installation of a road network that could promote the spread of alien plants and fragment habitats, and changes in microclimate in the operational site, invariably have ecological consequences throughout the food-web. But, in keeping with the general dearth of studies on taxa other than birds and bats, food-web effects have not been studied. Serious negative impacts upon groups

such as invertebrates are likely to have gone undetected. More could be done through habitat restoration to make wind farms wildlife havens and achieve the ultimate goal of a win-win scenario for wind energy and wildlife.

Ornithological Impact Assessment: Improving methodologies and reducing uncertainty for offshore wind farms

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Abstract

Offshore wind farms have become an increasingly important component of renewable energy generation. This is not surprising, since wind resources are greater, and landscape and visual impacts lower, when compared with onshore locations. Furthermore, the previously large difference in costs between on- and offshore wind farms is decreasing. In UK waters there are currently (as of February 2017):

- 31 operating offshore wind farms;
- 12 under construction;
- 10 with planning consent;
- 8 at an advanced planning stage; and
- Up to 16 in the early stages of development.

For economic reasons, offshore wind farms are located in shallower waters on the continental shelf. These waters are also rich in wildlife: British waters are among the richest in the world for seabirds, with a total breeding population estimated at 8 million individuals from 25 species. Consequently, there is a clear risk of significant impacts.

The main predicted impacts on seabirds are mortality due to collision with rotors and displacement from areas used for foraging or other activities. Methods for estimating impact magnitude and significance for these effects (e.g. collision risk modelling) are now well established, although uncertainty remains about the most appropriate values for certain key parameters. Although monitoring studies conducted at existing wind farms can provide some clarity, the rapid expansion of the industry, and increasing scale of developments, means the knowledge base has struggled to keep pace.

To obtain consent, offshore wind farms must assess their potential impacts both alone and cumulatively with other wind farms. As a consequence of parameter uncertainty, statutory agencies have adopted an understandably precautionary approach, based on worst case assumptions. While this approach rarely identifies significant effects for individual projects, as

the number of developments has grown, the magnitude of cumulative impacts has increased dramatically.

It is therefore conceivable that at some point the cumulative impact of offshore wind farms will reach a threshold of significant population impact, with no further developments able to obtain consent. This has led to increasing scrutiny of the precautionary assumptions made, in an effort to refine impacts and permit continued expansion of offshore wind.

We present some key examples of work conducted in the UK to illustrate how this process has developed. These include:

- A wide-ranging review of seabird population data (including ringing studies and GPS tag studies) to improve determination of appropriate populations for assessment;

- Adoption of sophisticated survey and analysis methods for site characterisation; and

- The use of age-structured, stochastic population models for estimating population effects.

By pursuing an evidence based approach to impact assessment we demonstrate how it has been possible to reduce uncertainty and reach agreements with statutory agencies such that predicted impacts have been refined to levels which have permitted developments to proceed. This process has also helped to focus attention on key areas of research which will contribute to further refinement of assessment methods. This last aspect is critical, given the expanding role of offshore wind in meeting renewable energy targets.

Bird and bat species' vulnerability to wind farms revealed through a global trait-based assessment of collision rates

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Abstract

Mitigation of anthropogenic climate change involves the deployment of different renewable energies worldwide, including wind farms. Wind farms can have negative impacts upon biodiversity. These include direct mortality through collisions or displacement from feeding or breeding areas, barrier effects to movement, and habitat degradation or loss. For airborne species such as birds and bats, the risk of collision is a serious concern and has the potential to reduce populations, particularly of long-lived, slow-reproducing species and wide-ranging or migratory species that cover a large area. Most study, however, into the impacts of wind farm collisions on species has taken place in industrialised countries, despite their global deployment, and the current or potential impacts of wind farms for many locations and species remain unclear. To redress this concern, we conducted a systematic literature review of the recorded collision impacts of birds and bats with wind farms within developed countries. We then carried out a trait-based meta-analysis, using Bayesian Generalised Linear Mixed Effects Models, to extrapolate the potential vulnerability of 9,825 bird and 888 bat species across all areas worldwide. We found that avian collision rate was affected by migration strategy, dispersal distance and habitat associations, whereas bat collision rates were negatively correlated with litter size. For both birds and bats, larger turbine capacity, assessed through megawatt output in turn correlated with larger physical turbine size, was associated with increased collision rates. A smaller number of turbines with greater energy output presented a smaller total collision risk for birds and bats, although total bat mortality may increase again with

the largest turbines. Areas with high concentrations of vulnerable bird or bat species were identified, which included migration corridors and bottlenecks (e.g. Mexico and Panama), among other areas. This is the first quantitative global assessment of the relative vulnerability of different species groups to wind farms. These results can provide valuable guidance in both wind farm design and location, to minimise large-scale animal mortality, particularly in areas with high concentrations of vulnerable species, and help avert potentially serious negative impacts on biodiversity.

Trophic webs comparison of two different habitats in the English Channel: the Courseulles-sur-Mer and the Dieppe-Le Tréport OWF case study

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Abstract

The French government has set a target of 23% of energetic consumption derived from renewable energy sources for 2020. With more than 11 million km2 of waters under its jurisdiction, France holds a huge natural potential for Marine Renewable Energy (MRE) and its exploitation could represent up to 3.5% of the national energetic consumption. France is planning nowadays the construction of six offshore wind farms (OWF) around its metropolitan coasts. Among them, two will be built in the Eastern part of the English Channel under a megatidal regime: the Courseulles-sur-mer OWF on coarse sands and gravels and the Dieppe-Le Tréport OWF on both coarse sands and gravels as well as on fine and medium clean sands.

These offshore wind farms will integrate into an ecosystem already subject to a growing number of anthropogenic disturbances such as transportation, fishing, sediment deposit, and granulate extraction. The possible effects of this cumulative stressors on ecosystem functioning are still unknown, but they could impact their resilience, making them susceptible to changes from one stable state to another. Understanding the behaviour of these marine complex systems is essential in order to anticipate potential state changes, and to implement conservation actions in a sustainable manner. Currently, there are no global and integrated studies on the effects of construction and exploitation of OWF. That's why we developed (1) a unique sampling strategy to collect data on the different compartments; (2) a methodology allowing the passage of the split vision which prevails in the current Environmental Impact Assessment to a holistic approach through the use of modelling tools such as Ecopath with Ecosim.

Trophic models describe the interaction between biological compartments at different trophic levels and are based on the quantification of flow of energy and matter in ecosys-

tems. They allow the application of numerical methods for the characterization of emergent properties of the ecosystem, also called Ecological Network Analysis. We present here the trophic web results (1) of two same habitats distant of $\sim$100 nautical miles from one another (the Couseulles-sur-mer coarse sands and gravels with Dieppe-Le treport coarse sands and gravels); (2) two different neighbour habitats (the Dieppe-Le Tréport coarse sands and gravels with the fine and medium clean sand), thus to highlight both similarity or difference between these three benthic habitats.

3 Poster Presentations

The impacts of a wind farm on breeding golden plover (*Pluvialis apricaria*)

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Abstract

There is evidence for negative associations between wind farms and breeding bird distributions. However; the magnitude, timing and causes of impacts remain uncertain, pending more detailed, robustly designed studies. The European golden plover, *Pluvialis apricaria*, has a distribution likely to overlap with developments and is a species for which correlative evidence suggests there could be a displacement response to wind farms. In one of the most detailed studies to date, we examined the impacts of a wind farm on breeding golden plover. We collected data from the wind farm, buffer and two control sites before, during and after construction. In addition to breeding abundance, data were collected relating to distribution, habitat preferences and breeding success. The considerable disturbance caused by the construction had no significant effect on golden plover abundance and a limited, but not significant effect on distribution. In contrast, operational turbines resulted in a significant loss of birds up to 400m from turbines; with no significant changes in abundance in buffer or control areas. Breeding success was not affected by proximity to turbine locations either during construction or operation. Key habitat variables did not change with turbine distance within the wind farm. The marked decline in abundance, during operation but not construction, together with the lack of evidence for changes in breeding success or habitat strongly suggests displacement of breeding adults through behavioural avoidance of turbines, rather than as a response to disturbance alone. Golden plovers breed in open habitats and turbines may alter perceived predation risk; changing the trade-offs between habitat suitability, potential breeding success and risk. We demonstrate the potential for large impacts of wind farms on bird distributions and the importance of detailed studies using data collected at all stages of development for better quantifying and understanding the impacts of wind farm construction on birds.

wind turbines provide foraging opportunities for bats in the Southern Great Plains, U.S.

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Abstract

Although the ultimate causes of high bat fatalities at wind farms are not well understood, several lines of evidence suggest that bats are attracted to wind turbines. One such hypothesis is that bats could be attracted to turbines as a foraging resource if the insects that bats prey upon are commonly present on and around the turbine towers. To investigate the role that foraging activity may play in bat fatalities, we conducted a series of surveys at a wind farm in north-central Texas from 2011-2015. First, we conducted acoustic monitoring of bat activity in the immediate vicinity of turbine towers to document foraging activity. Second, we searched for bat fecal pellets on and around the base of turbine towers for evidence that bats were using the wind turbines as a foraging resource and/or the tower structures as night roosts. Third, we used light trapping surveys to characterize the insect community on and around turbine towers. And fourth, we assessed bat diet composition using DNA barcoding of the stomach contents of 47 eastern red (*Lasiurus borealis*) and 24 hoary bat *(Lasiurus cinereus*) carcasses collected in fatality searches at the site. We then compared the turbine insect community to the diet analysis results.

In the acoustic surveys, we recorded foraging activity, including feeding buzzes indicative of prey capture, near turbine towers from all 6 bat species known to be present at this site. A genetic analysis of the bat fecal samples collected on and around the turbine tower bases likewise confirmed that the same 6 bat species were active near turbines and likely using the structures as night roosts, potentially between foraging bouts. From the light trapping surveys, we found Lepidoptera, Coleoptera, and Orthoptera in consistently high proportions over several years suggesting that food resources for bats were consistently available at wind turbines. Next, we found that the majority of the eastern red and hoary bat stomachs, the 2 bat species most commonly found in fatality searches at this site, were full or partially full, indicating that the bats were most likely killed while foraging. Although Lepidoptera and Orthoptera dominated the diets of these 2 bat species, both consumed a range of prey

items with individual bats having from 1 to 6 insect species in their stomachs at the time of death. Together, the light trapping and stomach content analyses revealed that the insects that were most abundant at wind turbines, including several important crop pests, were similar to the insects most commonly found in the stomach contents of eastern red and hoary bats. Collectively, these findings provide strong support for the foraging attraction hypothesis and indicate that mitigation measures should be implemented at wind facilities.

Comparison of results of bird and bat collision experiments in different habitat types in Austria in context with European fatality results

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Abstract

2003-2016 BIOME carried out five systematic collision experiments at different areas (lowland to high alpine areas) and habitats in Austria as well as at one site in Bulgaria (Via Pontica) with high numeric bird and bat activity. Around 5.500 hours were spent only on systematic carcass searches. Additionally a lot of non-systematic fatality searches at WT have been conducted to improve data, during ornithological fieldwork.

All systematic experiments are comprised of a circular search area (100m radius), tests of searcher efficiency and carcass removal, and the calculation of the mortality rate according to KRIJGSVELD et al. (2009) or KORNER-NIEVERGELT et al. (2015).

Because of the high variance of the documented bird and bat mortality rates in Europe (from 0 to >60 birds/WT/year (Spain) and 0 to 103 bats/WT/year (Germany)) it is difficult for the approving authorities to estimate the local collision risk for a certain wind farm planning area. Often the collision risk is estimated wrong, because incomparable study results are applied.

The collision risk highly depends on the local bird activity, as well as on the habitat type, altitude, geomorphology or bird migration pathways. Valuable meta-studies (e.g. Dürr: 09.02.2017: Bird fatalities at wind turbines in Europe) are very difficult to interpret for a local panning situation for non-ornithologists.

The comparative analysis of the documented mortality rates in Austria within the context of the European situation should help to better understand the collision risk on local and regional scales.

Frequent collisions of certain species are well documented (Common Kestrel, Common Buzzard, Goldcrest, Skylark) and can be predicted accurately in Austria.

In Austrian Lowlands the collision rate of migrating birds is low. Even at the important European migration route in Bulgaria (Via Pontica), the collision rate was astonishingly low.

A high number of collision victims are documented in special alpine habitats for migrating songbirds in Austria.

In general, local breeding birds in Austria are at higher collision risk than migrating birds.

Fallows under a wind turbine in the lowlands can cause considerably more collision victims for the Common Partridge and Pheasants and other species.

The collision risk of rare and often endangered species can only be predicted roughly because more long-term experiments are needed.

Collision avoidance strategies like down times for wind turbines for bats are efficient in the lowlands. The collision risk for bats in high alpine area is negligible.

It also has to be discussed why the collision avoidance methods for bats are already implemented successfully in Europe as a standard but until now the collision avoiding systems for birds are not properly developed and used. The technical components for an efficient collision avoiding system for birds are state of the art but an efficient system is still missing.

If I have to stop my turbines for bat conservation, how much does it cost? How can I scale the collision risk gained?

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Abstract

Because of the wind energy development and the bat mortality associated, in many projects wind turbines stop are planned to avoid collisions. In many cases the definition of stopped conditions are realised taking care of partial data crossed to bibliography and BACI monitoring.

Attesting and scaling the positive effects of stopping strategy is rarely done because of the imagined calculation complexity. Based on a probabilistically calculation, we propose a relative analysis to scale the risk reduction and the production reduction to compare different type of stop planning to choose the better one for risk and production reduction.

The principal consideration is that the main risk, 100%, is due to the project without any regulation. So if we compare for a same bat activity wind data (bat activity according to wind speed, wind quantity per wind speed), wind turbine data (angular speed per wind speed), and bat activity phenology (bat activity level per hour after sundset) and wind exploitation regulation plan, it is possible to compare the relative risk indicator for the project including stopping or not.

The process is built with calculations crossing the integrated data as: bat activity per time after sunset, bat activity depending on wind speed, wind turbine angular speed per wind speed, wind quantity per wind speed, stop regulation plan, and produce a relative risk indicator which allows relative comparisons as percentage of collisions mitigation.

In this condition it is possible to define ,based on objective considerations, the better compromise for a bat protection and electricity friendly production regulation plan. Because of a multidimensional analysis, 3D graphic representations are able to be done, and because of the simplicity of the calculation architecture it allows to easily realise calculation simulations even for low issue project.

Offshore wind farms: heaven or hell for guillemots? First result of the project HELBIRD

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Abstract

Common Guillemots (*Uria aalge*) belong to the most abundant species in the North Sea and show a widespread distribution. Most of the studies dealing with wind farm effects on distribution patterns detect that guillemots avoid wind farms to a varying extent. In some wind farms numbers of observed guillemots strongly decreased compared to pre-construction situations, whereas in some other wind farms the distribution did not change or numbers even increased.

Because of the high numbers of wind farm developments all over the North Sea it is important to analyse distribution patterns and behaviour in response to offshore wind farms in as many areas as possible.

The only breeding site for seabirds in the southeastern North Sea is the island of Helgoland. Nearly 3300 pairs of Common Guillemots breed on the cliffs of this island.

In a distance of 20 – 40 kilometres north of Helgoland three large offshore wind farms have been constructed since 2014. These wind farms are located in an area that is not only used by breeding birds of Helgoland but also by other resting seabirds as well as marine mammals.

Because of the importance of this region for marine top predators the project HELBIRD was funded by the Federal Ministry for Economic Affairs and Energy to analyse the distribution as well as behavioural patterns of seabirds and marine mammals in response to offshore wind farms. Part of this project amongst others are digital aerial surveys, conducted to analyse the occurrence of birds and marine mammals in a radius of about 10 km around the wind farms.

First results show that Common Guillemots only occur in small numbers and rarely inside these offshore wind farms. The goal of this study is to answer the question which parameters affect the distribution patterns of Common Guillemots and to analyse possible avoidance distances to the wind farms.

Monitoring of bats in wind turbine projects: A stakeholder-based assessment of methods

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Abstract

Germany is undergoing a rapid transition from conventional energy production (both fossil and nuclear power) to renewable energy sources. Wind energy production is pivotal as part of this process, yet two vertebrate taxa are most often affected by wind turbine projects, namely birds of prey and bats. Therefore, conservation aspects related to these two taxa have to be considered in almost all planning processes. Accordingly, federal countries of Germany have published guidelines about suitable methods, yet the efficiency and relevance of some of these methods is under strong debate among specialists. Therefore, we sent out an online questionnaire to stakeholders (environmental authorities, consultants, members of wind energy companies, conservation NGO, scientists) and asked them about the suitability and efficiency of selected methods, namely radiotracking, mistnetting, acoustical monitoring and carcass search. Here, we report on this stakeholder-based evaluation of methods. Radiotracking of bats was acknowledged as a suitable method in forests, particularly for the maternity period. Mistnetting of bats was considered appropriate for forests in search for roosts, yet mistnetting was rated inappropriate for the migration period and also for non-forest sites, such as agricultural areas. Acoustical monitoring of bats via transect walking with bat detectors was rated unsuitable. Yet, ground monitoring was considered useful by consultants when done with automated stationary systems. Acoustical monitoring at the nacelle height of wind turbines was rated suitable by all stakeholders. Consultants pointed out to some discrepancies between acoustical activity of bats at nacelle height and the estimated number of carcasses below wind turbines. In general, the estimation of carcasses numbers was rated questionable by both authorities and consultants. Based on our evaluation it is now possible to recommend the most appropriate methods for monitoring bats during the development of wind turbine projects.

Additional energy costs and avoidance patterns of swans and geese associated with an onshore wind farm in Japan

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Abstract

The impact of the barrier effect of wind farm presence on bird migration, such as avoidance behaviours and additional energy costs, is poorly understood. To our knowledge, Masden et al. (2009) is the only study that has reported the additional energy costs of birds' avoidance response to an offshore wind farm. According to Masden et al., the barrier effect on offshore migration of common eider (*Somateria mollissima*) is assumed relatively small in terms of estimated energy costs. However, the impact may be different among bird species because of the variety of their flight speed and navigation. Moreover, the impact may be different between offshore and onshore wind farms due to the terrain difference, such as presence of mountains. Therefore, it is necessary to assess the barrier effect on various migratory bird species at onshore wind farms. To do this, we obtained flight trajectories of whooper swan (*Cygnus cygnus*), tundra swan (*Cygnus columbianus*) and greater white-fronted goose (*Anser albifrons*) during spring migration by using radar tracking around an onshore wind farm located in the northern part of mainland Japan. These bird species are particularly concerned in Japan. We characterized the flight trajectories, such as minimum distance to the wind farm and bearing angle. Additional flight distance of the avoidance response was estimated from the curvature of the flight trajectory. Then additional energy costs of the avoidance response were estimated using a biomechanical model. We compared the avoidance response, flight speed, and energy costs among the three species. The latest results on energy costs and avoidance patterns will be presented. Additionally, we are fitting the flight trajectories to an avian movement model. Our approaches can contribute to the environmental assessments of wind farm developments.

Wide-scale movements of lesser black-backed gulls throughout the year and implications for cumulative impact assessments of wind farms

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Abstract

Wind energy generation is an alternative to fossil fuels and is important for combating human-induced climate change. As an industry, it is also growing rapidly worldwide, both onshore and offshore, but with increasing structures placed in the environment, it could represent a significant threat to avian populations. The potential impacts of wind farms on bird populations include direct mortality due to collision with turbines/infrastructure, physical habitat modification and/or loss, and avoidance responses of birds to turbines. Of these, the risk of collision mortality has received the most attention to date. However, despite the fact that birds may be impacted by collision mortality with wind turbines throughout the year, the relative vulnerability of populations across the annual life-cycle has not been evaluated. This may be of particular importance for migratory species and in relation to the assessment of cumulative impacts. Cumulative impacts can be considered the additional changes caused by a wind farm development in combination with other similar developments or activities. However, the range of activities that should be included in such assessments and the scale over which they should be conducted is often vague.

Using a case study of the lesser black-backed gull *Larus fuscus*, we demonstrate how GPS telemetry can be used as a tool to quantify potential vulnerability across the entire movement range of this species. Between 2010 and 2015 we studied the movements of 74 adults from three colonies of lesser black-backed gulls in the UK throughout their annual cycle. We modelled the distance travelled by individuals, between the minimum and maximum rotor sweep zone, as an index of potential risk to existing wind farm installations. This risk surface was then combined with wind turbine density, which represented an index of exposure, to evaluate spatio-temporal vulnerability.

The potential risk was highest near to colonies during the breeding season, where a greater relative distance was travelled due to the constraints of chick rearing and the act of central-place foraging; this resulted in high vulnerability, despite lower exposure through reduced wind farm densities in these areas. Vulnerability, however, was also high at some migration bottlenecks and key wintering sites where, despite a reduced potential risk, exposure was much greater.

We show for the first time, how GPS telemetry can be used to reveal hidden complexities of vulnerability for migratory species to wind energy developments across the year and over international boundaries. These novel results highlight the importance of fully considering cumulative effects when evaluating the potential impacts of wind farm developments on populations of a wide-ranging species. Our approach can aid the wind farm planning process by identifying key areas where a species may be vulnerable throughout its range, or existing areas where mitigation measures warrant exploration. In addition, these methods in this study are fully transferable to resolve other human-wildlife conflicts to further species conservation.

Avoidance behaviour of migrating raptors approaching a Danish offshore windfarm

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Abstract

The last decade has witnessed a massive expansion in large offshore wind farms, in particular in the UK, Denmark, Germany, The Netherlands and Belgium. Typically, the major environmental concerns have been the risk for birds colliding with the turbine wings and birds being displaced from feeding and resting within the wind farm area. While a barrier effect of offshore wind farms has been described for migrating geese and ducks, little attention has been given to a potential barrier effect of large offshore wind farms to landbirds when constructed across bird migration corridors.

Most migrating raptors tend to avoid water crossings whenever possible. To shorten over-water travel, these raptors often migrate the length of a peninsula before making a sea crossing and many also island hop to reduce the risks associated migrating over the sea (such as high energy expenditure if weather deteriorates). One such peninsula is Djursland in Denmark. Here raptors concentrate in spring before departing E or NE to cross some 40 km Kattegat (Baltic Sea) to the island Anholt and from there the additional 50 km across the sea to the Swedish coast.

In 2013, Anholt Offshore Wind Farm (AOWF) was installed halfway between Djursland and Anholt. AOWF consists of 111 wind turbines (3.6 MW each) arranged in up to 20 km long rows perpendicularly to the flightpath used by the migrating raptors.

This study investigated the barrier effect of the AOWF on migrating raptors by quantifying macro avoidance behaviour defined as a change in raptors' flight direction in order to avoid entering the wind farm. Behavioural data of the migrating raptors were compiled during three spring seasons (2014-2016) using 30x binoculars, marine surveillance radar and laser range finder from an offshore transmission station located 1.75 km west of the nearest turbine of the AOWF.

Macro-avoidance ($n = 151$) was observed for $1/3$ of the migrating raptors, including 59% of the Red Kites (*Milvus milvus*), 45% of the Kestrels (*Falco tinnunculus*) and 42% of the Sparrowhawks (*Accipiter nisus*). After migrating almost 20 km over the sea, about 75% of

these birds turned and flew back towards Djursland while the rest continued perpendicular to the wind farm without entering the farm for as long as they could be visually observed or followed by radar. This strongly suggests that the AOWF acts as a barrier preventing these birds from crossing Kattegat at Djursland or significantly prolonging their migration route.

Our data and recent observations suggests that only moderate numbers of raptors use the Djursland – Anholt – Sweden migration route in spring. Therefore, the observed barrier effect has most probably only limited impact at population level. However, macro-avoidance behaviour of the scale observed at the AOWF could potentially have significant impact on raptor populations if the offshore wind farm is located across a major raptor migration route.

Searching frequently or searching far? Precision and bias of bird fatality estimates from two contrasting carcass detection strategies

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Abstract

Carcass monitoring at operational onshore wind farms in the UK is rarely stipulated in planning conditions unless a specific risk to a valued ornithological receptor has been identified during consenting. Data from systematic carcass searches could provide a valuable evidence-base with which to quantify mortality at regional and national scales, validate pre-consent collision risk assessments, and inform future consenting decisions. However, the high labour costs often involved in carcass searching means there is little incentive for wind farm operators to collect these data voluntarily. If however, carcass searches could be carried out incidentally during routine turbine inspections it could allow data to be collected at lower cost. This leads to the question of how, given a limited amount of effort available, a search should be conducted: would it be preferable to search a smaller area with higher frequency or a larger area with lower frequency? Here we use simulations to compare the precision and bias of fatality estimates resulting from two contrasting search methodologies: weekly searches of turbine hardstandings or monthly searches of a 50 m radius of turbines.

Carcass searches are subject to imperfect detection due to various biases; some carcasses fall outside the searched area, some are removed by scavengers, and some are not found by searchers. We extracted plausible rates for these biases for different bird groups (large and small sized raptors and non-raptors) from the literature to input into simulation scenarios for each bird group assuming different annual mortality rates (1, 5, and 10 fatalities per year) and monitoring durations (1, 5, 10 and 25 years). One thousand simulations were run for each scenario and the bias (estimated number of fatalities minus true number of fatalities divided by the true number of fatalities from all simulations during which at least 1 fatality occurred) and precision (95% credible intervals) of fatality estimates resulting from both search strategies were calculated using the Korner-Nievergelt fatality estimator.

Simulations indicated that monthly searches within 50 m of turbines produced fatality estimates that were more precise and less biased than those from weekly searches of hard-

standings, particularly when carcass persistence probability and searcher efficiency were high, such as raptors and large non-raptors. Estimates from both methods were equivocally biased and imprecise for species with low persistence probability and searcher efficiency, such as small non-raptors, particularly when monitoring lasted for only one year. When annual mortality rates were low (e.g. $<$1 fatality per year) both strategies produced biased and imprecise fatality estimates unless monitoring continued for $>$10 years. The exception being monthly searches of large areas for birds with high persistence and search efficiency (raptors and large non-raptors), which could detect even low mortality rates with reasonably accuracy and precision. At higher annual mortality rates ($>$5 fatalities per year) accurate estimates were attained after 5 years of monitoring using either method.

Both search strategies could provide useful fatality estimates depending on the particular species of interest, duration of monitoring, and expected annual mortality rates. We discuss the implications of our findings and make recommendations highlighting limitations where incidental carcass searching may not be appropriate.

A modelling approach to identify peat depth and its use within habitat management plans

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Abstract

Peat bogs are a valued feature across many upland areas of Wales. These upland areas also provide a good wind resource, which has lead to many wind farms being located in these areas. As a result of the planning process, many wind farm developments commit to the restoration of the peatland on which the wind farm is located, often through the implementation of a Habitat Management Plan (HMP). Natural Power Consultants Ltd were commissioned to produce a HMP for the Pen y Cymoedd Wind Farm in South Wales. The development comprises of 76 turbines and has a proposed HMA of 1441 ha. In order to identify the macrotope peat bodies present within the HMA, peat depth information was required. Due to the extent of the HMA and the labour costs associated with peat probing the entire area, a peat depth modelling approach was adopted. Predictive models of the presence of deep peat given three predictors (slope, elevation and topographic wetness index) were built with boosted regression trees (BRT), with 10-fold cross validation, using the dismo package[1] in R[2]. Peat depth data were divided into a training dataset, used to calibrate the models, and a testing data set, used to evaluate model predictive performance. Eight models were fitted in total, each with different settings. The best model contained 3200 trees and classified 75% of the test data correctly. The top model found that slope and elevation were the most influential predictors, with relative contributions to the model of 39% and 36%, respectively. Topographic wetness index contributed 25% to the model. The predicted extents of deep peat within the HMA were mapped using this model which was then used to inform the habitat management prescriptions for the site. This model provides a valuable resource for rapidly assessing and understanding the presence of deep peat habitats present within a site.

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ConSite Wind: Consensus based siting of wind power

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Abstract

The expansion of wind energy development causes both societal and environmental concerns worldwide. Traditional land use planning approaches however limit addressing such concerns adequately. The scale and complexity of emerging renewable energy construction projects enforce the development of improved plan- and decision support tools that ensure democratic and cost-effective processes securing qualified decision making. The multiplicity of criteria and actors involved in decision-making processes requires holistic approaches that enable capturing the variety stakeholder views from technological, economic, societal and environmental perspectives. As a response to this societal need, NINA has developed a Spatial Multi-Criteria Decision Analysis tool (SMCDA) for siting of onshore wind-power plants and associated infrastructure such as powerlines and roads. The tool ConSite (Consensus Based Siting) aims to ensure social acceptable, environmental friendly and cost-effective siting and design of wind-power plants. ConSite helps to identify and justify decisions taken with respect to both transparency and re-examination. ConSite is based on current developments in stakeholder dialogue theory, GIS-based Spatial Multi-Criteria Decision Analysis (SMCDA) and decision theory. The ConSite framework is structured into the operational steps of a classical SMCDA and combines stakeholder dialogue for multi-criteria assessment, their valuation and weighting; decision strategies for criteria aggregation and sensitivity analysis of these for identifying and comparing the optimal sites for wind energy development. ConSite thus helps structure decision problems, balance conflicting interests and identify relevant decision strategies based on risk assessment and trade-off analysis. ConSite provides scenario capabilities to predict spatial consequences of different decision strategies enabling the balancing of local conflict levels with local production potential in different ways. ConSite is currently implemented in spatial planning of wind-power development in Lithuania and siting of fish farms in central Norway. The toolbox has previously been successfully validated in a power line routing case-study in South-Trøndelag (Bevanger et al., 2014). Further development to integrate the ecosystem services concept into an adaptive landscape planning context, helps making the complexity

of social-ecological systems more comprehensible for involved stakeholders. This enables the application of ConSite across sectoral interests (e.g. renewable energy, road infrastructure, urban development and fish farming). Building upon a variety of examples, this talk will explain the ConSite tool concept and how it can be applied in practice. ConSite can thus help decision makers to secure social acceptable, environmental friendly and cost-effective siting and optimal design of renewable construction projects.

High-resolution spatial modelling of landscape geomorphometry and updraft landscapes to forecast risk-enhancing topography for bird-friendly micrositi

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Abstract

In current international wind energy projects there is a particular concern about the extent of bird (and bat) collisions. Possible mitigation approaches to reduce collision risk can be categorized as turbine-based or bird-based. The turbine-based mitigation approach includes measures like wind farm design, turbine micro-siting, repowering and operational measures. Such turbine-based measures have small or only indirect effects on bird behaviour, but may effectively reduce bird mortality. A turbine-based wind farm design will normally, depending of the local context, have to balance technical factors (e.g. wind conditions, topographical constraints, turbine design, turbine numbers and turbine micro-siting) with economic factors (e.g. cost-efficiency), societal factors (e.g. noise, visual impacts and shadow flickering) and environmental factors (e.g. movement corridors and bird collision risk). Several engineering tools for wind resource assessment, energy yield calculation, wind farm siting and wind turbine micro-siting on the market today addresses technological, economical and societal factors (e.g. WaSP, WindSim, ECN WakeFarmer and GH WindFarmer), while none of them provides functionality for forecasting risk-enhancing topography related to movement corridors and bird collision risk. As a response to this, NINA developed in 2014-2016 a GIS-based tool for bird-friendly micrositing of wind-turbines (INTACT Micrositing GIS) as a part of the Norwegian R&D project "Innovative Mitigation Tools for Avian Conflicts with wind Turbines (INTACT)". The INTACT Micrositing GIS tool provides functionality for spatial modelling of migratory corridors and updraft landscapes. The tool utilizes state-of-the-art algorithms in geomorphometric, orographic and thermal updraft modelling, and has a spatial resolution of 10 x 10 meter making it highly relevant for fine-scale micrositing of wind turbines. The high spatial resolution makes the INTACT Micro-siting GIS tool unique compared to similar thermal updraft modelling which is mainly based on weather forecast models with spatial resolutions ranging from 12.5 x 12.5 km to 32 x 32 km. The updraft models of the INTACT Micrositing GIS tool was successfully validated with high-frequency GPS tracking data for

white-tailed eagle at the island of Hitra in Norway and for black kites in the Tarifa area in Gibraltar, Spain. The INTACT GIS Micro-siting tool has a user-friendly interface and is suitable for pre-construction impact assessments and micrositing of wind turbines. The tool can be further developed as an add-on to existing engineering tools .

Bat flight height monitored from wind masts predicts mortality risk at wind farms

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Abstract

Bat fatalities by collision or barotrauma at wind farms currently raise high conservation concerns. In many countries, pre-installation acoustic surveys are mandatory in order to assess the impacts of wind farm projects. In this purpose, the use of wind masts to estimate bat activity and hence predict collision risk is highly recommended by conservation committees worldwide. Yet, the degree to which collisions may be predicted from acoustic monitoring at wind masts has been strongly debated.

To assess this relationship, microphone arrays were installed on 23 wind masts in order to record and locate bat activity on the vertical axis during 3,260 nights. For each species, we also calculated a collision susceptibility index, based on fatality data gathered in the literature and corrected for species abundance. We demonstrate that the collision susceptibility index is correlated with the time spent at blade height.

The acoustic recordings allowed us to establish a reference for the flight heights of 28 European bat species. The correlation we demonstrate here between the time spent at height – recorded from acoustic surveys on wind masts - and bat fatalities strongly supports that activity estimates from wind masts are appropriate for wind turbine impact assessments.

Highlights:

- The most complete dataset of bat altitudinal flight behaviour is presented
- A bat collision susceptibility index to wind turbine collisions was calculated
- The collision susceptibility index is correlated with time spent at blade height
- Results support the relevance of using wind masts for impact assessment studies

French onshore wind farms and their direct impact on birds - Review of bird mortality surveys conducted between 1997 and 2015 in France

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Abstract

France has the fourth largest cumulative installed wind energy capacity in Europe. Installed wind generation capacity is expected to reach 10 to 12 000 turbines to the end of 2023. Although surveys have been carried out on avian mortality due to collisions with wind turbines in France, they were never compiled and analysed at national scale. The objective of this study is to provide a comprehensive review about bird mortality surveys conducted between 1997 and 2015 in France.

Through an extensive literature review, we were able to collect 197 reports in which data on bird collisions with wind turbines can be extracted and combined with information on carcass survey protocol and facility-specific information. We reviewed timing and taxonomic composition of bird fatalities collected at 142 wind farms and examined risk factors associated with these fatalities such as turbine size and location. We discuss these results in the context of the 5 105 onshore wind turbines operational in France in early 2016.

A total of 1 102 carcasses belonging to 97 bird species have been reported. Passerines comprise 49% of all fatalities followed by raptors (23%), gulls (11%) and swifts (11%). Common Firecrest, *Regulus ignicapilla*, were the most common species found under wind turbines, followed by Common swift, *Apus apus*, and European Kestrel, *Falco tinnunculus*. 8% of the species found at the turbines are listed in the threatened species categories of the Red List of Threatened Species and 10% are included in Annex I of the Bird directive. The highest numbers of carcasses were reported during autumn and late summer and the lowest in winter, season poorly covered by the surveys. On average, 0.02 bird carcass had been found per passage (i.e. 1 carcass every 45 passages) but sampling methods vary considerably from one park to another, making comparison between studies difficult. On average studies of collision mortality were conducted over a 26 weeks period ($\pm$SD 14) with 1 search for carcasses per week ($\pm$0.8) on a radius of 50 m ($\pm$13) around wind turbines. Estimations of bird fatalities using dedicated formulas are only provided for 8 wind farms. With a mean annual

collision rate of 7.8 birds/turbine ($\pm$8.3, min-max=0.3-26.8), these results are consistent with those reported in other studies. We were not able to find any correlation between the number of fatalities and the land cover type (open fields vs. others). In the same way, number of facilities was not correlated with size of turbines. The biggest ´bird-killers´ are the old small wind turbines which have been settled in areas of high ornithological interest. Wind farms located near to or in Special Protection Areas (SPAs) designated under the Birds Directive experienced significantly higher fatality rates. For that reason, we fully support previous recommendation to keeping clear SPAs in future plans for wind farms. The dismantling of old wind turbines should be viewed as an opportunity for not renew construction and operation authorizations of the most problematic ones.

Bats and wind energy in Southern Spain: temporal patterns and potential consequences for wind power facilities management

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Abstract

The impact of wind turbines on bats have hardly been considered until recent years. In this study we analyze bat fatalities occurred in southern Spain (province of Cádiz) between 2009 and 2014. We characterize species composition and temporal patterns of the fatalities, in order to identify the periods of maximum risk in the study area. The information concerning bat mortality was provided by the Regional Environmental Agency (Junta de Andalucía). A total of 1810 bats killed by turbines were recorded in the six years of study. The majority of the bats collided in the wind turbines fell within the following groups: genus Pipistrellus (*P. kulhii*, *P. pipistrellus* and *P. pygmaeus*; 66.61% of fatalities), genus *Eptesicus* (*E. serotinus* and *E. isabellinus*; 17.78%) and genus *Nyctalus* (*N. lasiopterus*, *N. leisleri* and *N. noctula*; 3.71%). The rest of dead bats belonged to some other genera such as *Barbastella*, *Hypsugo*, *Miniopterus*, *Myotis*, *Rhinolophus* and *Tadarida*, whereas in some cases the identification of genus of the carcasses was not possible. Most of the mortality affects to species living in forest and crevices, with a significant impact on threatened species, as *Nyctalus lasiopterus* and *Nyctalus noctula*.

For the temporal analysis of fatalities, we standardized the total number of incidents calculating the rate of collisions per wind turbine and per unit of year. The bats of genus *Pipistrellus* suffered mortality all year round, while the rest of species showed specific temporal patterns, starting in early spring, and in all cases the highest impact was concentrated during the summer and early autumn.

Our results suggest that in southern Europe the period of risk for bats concerning wind-farms may be longer than showed by previous studies in northern areas, extending throughout the year for some species, that can be related to longer activity periods in mild southern winters.

This information is also useful for the Environmental Authority, since it should allow the design of specific monitoring plans for these areas, which cannot be directly extrapolated from other pre-existing ones in more northern countries.

Bat activity at nacelle height over forests and open landscape

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Abstract

The rising number of wind turbines in Germany is increasingly affecting bats, especially onshore. Currently, forested areas are regarded as suitable sites to further increase renewable energy production through wind energy. Forests play a crucial role for most bat species as hunting grounds and/or roost sites. Knowledge about how wind turbines in forests affect bats, however, is rudimental. Besides the obvious destruction of roost sites and hunting habitat, collision with operating wind turbines is likely to be the most problematic effect.

Recent studies on the effect of wind turbines on bats focused on open landscape, mainly because forested areas were not yet considered for wind energy production. In recent years however, wind turbines are constructed in forests more commonly, mainly in the forest-covered hillsides of Western and Southern Germany. Up to now, data collected at forest sites was not analysed in a large scale. In the research project "Construction and operation monitoring of wind energy in forests", funded by the Federal Ministry for Economic Affairs and Energy (BMWi), a large set of acoustic monitoring data was gathered and analysed, collected at 130 wind turbines at nacelle height over forests and open landscapes from all over Germany. We used descriptive statistics as well as linear mixed effects models to present and analyse the influence of habitat and geographical region on bat activity at nacelle height.

The results show that bat activity over forests shows very little differences to open landscapes. Daily and annual phenologies, as well as species composition, are similar in forests and open landscapes, however, influenced by the geographical region. These results suggest that mitigation measures, developed to reduce bat fatalities in open spaces, are also applicable to wind turbines placed in forests.

Mortality and displacement of birds at small wind turbines

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Abstract

Wind turbines along with other renewable energy technologies form an important part of strategies to reduce greenhouse gas emissions worldwide. Although generating much less energy than large turbines, small wind turbines (capacity less than 100 kW) have become very popular in Northern Germany. Being often installed close to farm yards which are rich in bird life, small wind turbines may pose a considerable collision risk to farmland birds and they potentially displace birds from their original habitats. Former studies found little displacement effects on birds by small wind turbines. Collision risk, however, has so far not been studied to a greater extent. The aim of our study, which is funded by the German Agency of Nature Conservation, is to quantify the impact of small wind turbines on birds and to direct the application process for the installment of small wind turbines.

We studied 14 different small wind turbines in Northern Germany. A team of observers searched for collision victims once a week from 1st July 2015 onwards. Carcass persistence rate, search efficiency and the probability that a killed animal actually lands in the area searched were recorded. Fatality rates were extrapolated using the method and software supplied by Korner-Nivergelt et al. (2013).

In addition, all birds present in an area with a diameter of about 250 m around the turbines were mapped once per week. Observers recorded how close birds approached the turbines and noticed changes in flight direction in relation to the wind turbine. The entire observation protocol was repeated on 14 control sites without wind turbines in the vicinity of the respective study site at the same dates.

During the first 18 months of the study we found five collision victims: two Western Jackdaws *Corvus monedula*, one Carrion Crow *Corvus corone*, one Common Starling *Sturnus vulgaris* and one White Wagtail *Motacilla alba*. The total number of fatalities was estimated at 20 (95% confidence interval 9 – 40). This translates into about one collision victim per turbine per year. The species affected were all common at the study sites.

If at all hardly any displacement of birds by small wind turbines was observed. Our study, however, shows for the first time that there is a considerable risk for birds of colliding with the turbines. None of the species found is endangered or red-listed. Jackdaws tried to nest in one type of turbines and the fatalities seemed to be related to nesting attempts. The obvious recommendation is to close cavities in the turbine that might serve as nesting places. It is likely that the collisions of other species are a function of their densities around the turbines. As the density of birds in our study sites was affected by the presence of hedgerows and buildings the recommendation is to place small wind turbines well off hedgerows and houses. It should be noticed that the bird collision rate per produced unit of electric energy at small wind turbines is much more than 10-fold of those of large turbines.

Measuring the impacts of offshore wind developments in the North Sea region on cetacean species: Developing SDG14 indicators for transparent monitoring

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Abstract

This scientific work focusses on developing indicators which measure the impacts of offshore wind developments (OWDs) in the North Sea region on marine mammals, especially cetaceans. Recognizing the increased number of operational offshore wind farms existing at various areas of the North Sea and also at the coastal habitats of neighbor countries (Norway, Denmark, Germany, the Netherlands, Belgium and the UK), this article proposes that there is a high pressure observed from OWDs upon marine mammals and their living habitats. The industrial pressure created by the commissioning, operating and decommissioning of offshore wind farms affect marine ecosystems along with cetaceans on the grounds of biodiversity and underwater vitality. Therefore, this academic work aims at developing transparent and comprehensive indicators to monitor the possible negative and positive impacts of offshore wind farms upon marine mammals (cetaceans) including all construction and facilitation phases, so that oceans can be governed sustainably. Upon this point, this article suggests that the indicators that are developed for Sustainable Development Goals, *Goal 14: Life Below Water* are lacking in accuracy and transparency, since they do not indicate for species specific and site specific data. In order to fill this knowledge gap, this work combines site-specific data acquired directly from Environmental Impact Assessment reports of 33 operational wind farms in the North Sea region with the species specific data provided by different stakeholders such as IUCN, International Whaling Commission, Whale and Dolphin Conservation Society and Joint Nature Conservation Committee. As another method in use, this scientific work applies the academic support of Sea Mammal Research Unit, University of St. Andrews; Institute of Biological & Environmental Sciences, University of Aberdeen and Institute for Marine Resources and Ecosystem Studies-IMARES, the Netherlands. Preliminary results of this research show that there are at least two categorical significant impact groups which are caused by OWDs in the North Sea upon cetaceans: short term impacts and long term impacts. Electromagnetic impacts due to cabling which affect navigation of the cetacean species, increased vessel traffic

from construction and maintenance operations and the continuous operational noise and vibrations emanating from the wind turbines can be included in short term impacts. The long term impacts on the other hand are consisted of seismic exploration, intense noise due to ramming/piling, drilling and dredging operations, increased turbidity due to construction and cable laying and the use of explosives during the decommissioning of the offshore wind farms. The behavior and the abundance of the cetacean species differ before and after these impacts have been observed. This comparison is critically made by this article while using the data from SCANS-I, SCANS-II and SCANS-III marine and aerial surveys that are conducted by ASCOBANS. After the consolidation of data for impact monitoring indicators, this paper aims at improving the precision level of UN SDG 14 indicators while suggesting marine-site specific and species-specific monitoring data to be included by the goal Life Below Water, to use oceans and seas more sustainably by all means.

Demonstration of good practices to minimize impacts of wind farms on biodiversity in Greece

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Abstract

In scope of European Union's 2020 objective to produce 20% of total energy production from renewable energy sources, a drastic development of wind farms in Greece is anticipated in the near future. This development is expected to cause increasing conflicts of energy production with wildlife and nature conservation. In order to minimize the impacts of wind farm on wildlife and particularly on birds and bats, the LIFE project "Demonstration of Good Practices to minimize impacts of Wind farms on Biodiversity in Greece" (LIFE12BIO/GR/000554, www.windfarms-wildlife.gr) promotes state-of-the-art methods, technologies and approaches to improve the compatibility of wind farm development with the EU biodiversity conservation objectives and develop prescriptions and guidelines that will enable Greek state authorities and wind farm developers to effectively plan, implement and regularly evaluate the performance of the mitigation technologies. For this purpose the operation of modern technologies, including radar, thermal imaging, video surveillance and bat detection, is being demonstrated at CRES demonstration wind farm at Keratea Attikis, as well as, commercial wind farms. This demonstration is further supported by specifically designed and produced Good Practice Guide, Decisions Support Tool and other communication material which are promoted to key stakeholder groups, including central and regional authorities, wind farm developers, NGOs and management authorities of protected areas, through numerous meetings, presentations and the operation of the project's Advisory Committee. The preliminary results of the demonstration operation have already highlighted the capabilities and limitation of applied technologies under different environmental conditions in Greece and are being utilized by the competent authorities as well as wind farm developers to reduce impacts of particular wind farms on birds and bats, with special reference to mitigation of collision risks. The active involvement of all key stakeholder groups in the project's Advisory Committee in association

with the results of the demonstration operation and tools developed by the project are expected significantly to improve the capacity of competent authorities, wind farm developers and nature conservation institutions in finding optimal solutions sustainable planning of wind farm development in collaboration with nature protection in Greece.

Integrated analytical solution for long-term quantitative monitoring of bird movements by radar

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Abstract

Introduction: Impact assessment studies are required prior and sometimes after construction of wind farms and such studies typically involve the quantitative monitoring of bird movements. Radar is an approved tool to detect flying birds and it operates under almost all conditions. However, a proper quantitative monitoring of bird movements by radar requires additional analytic steps, such as echo detection, classification, selection of bird-echos, estimation of bird size, estimation of shape and volume of surveyed space, and finally computation of the rate of animals flying in a given height layer. We will present the BirdScan MR1 radar system, which integrates all these steps, and illustrate how results are used within an impact assessment study.

Radar device: The BirdScan MR1 radar system has a conically shaped vertical-looking beam, it detects birds, bats and insects and can operate continuously and autonomously. The beam illuminates a passing animal during several seconds, thereby the fluctuation of the echo intensity is recorded and this pattern (e.g. wing flapping) is then exploited by the analytics modules. The slightly nutated rotating beam allows calculation of flight direction and speed of individual targets.

Radar analytics module: The separation of bird echos from the often-abundant insect echos is a prerequisite for quantitative monitoring of birds. Moreover, classification of bird echos into functional sub-types and size classes (based on wing-flapping pattern) is necessary to approximate the surveyed volume and ultimately compute Migration Traffic Rates. The automated classifier is based on established Machine Learning methods (Random Forest classifier). The module for automated estimation of Wing-Flapping Frequency (WFF) is based on a Random Forest regression model. Performance of classifier and regression modules were assessed by training models with data from two sites and validating with the third "left-out" data set. For separating *bird* from *non-bird* echos, a classification accuracy above 90% was achieved. For WFF estimation the correlation with the true WFF was above 0.90.

Analysis outputs for impact assessment: The integrated system provides a rich set of analysis outputs which are valuable for impact assessment studies. Several types of analyses will be presented, such as daily/nightly migration intensity over a whole season, hourly migration intensity averaged over several days, height migration profiles, or per-night direction distribution.

Discussion and outlook: The radar system provides detailed data on each individual flying animal for all relevant heights. This large quantity of raw data can be integrated and transformed to informative outputs thanks to modern data-analytic methods. The system's horizontal range is limited as compared to meteorological radars and it is therefore complementary to these systems. Future work should focus on developing networks of MR1 radars, probably integrated with other data sources, which would ultimately allow the prediction of bird movements at a regional scale.

Wildlife Monitoring and Reporting System using Operations and Maintenance Personnel: 5-year Assessment

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Abstract

This study is the first investigation of the validity of a long-term Wildlife Monitoring and Reporting System (WMRS) using operations and maintenance (O&M) personnel to assess potential operational impacts (numbers, species composition, trends) to wildlife resources from wind plants across the United States.

The goal of the program is to achieve a level of sensitivity that assesses impacts to wildlife integrated with everyday maintenance while encouraging wildlife awareness. The objectives related to birds and bats fatalities were:

- Document numbers of fatalities and identify large (>5) fatality events;
- Document species composition;
- Determine trends at wind plants.

This presentation focuses on the first five-year assessment (2011-2015) of long-term operations monitoring to meet these objectives. WMRS is completed through voluntary, long-term monitoring conducted by O&M personnel recording wildlife injuries and fatalities at fleet-wide plants. Long-term monitoring consists of: 1) Environmental Coordinator (EC) inspections (standardized weekly searches in fall and spring) along access roads and pads ($>$ 17,900 inspections), 2) monthly turbine checks of base pads ($>$ 170,000 checks), and 3) incidental observations fleet-wide (2015 - 48 plants). Bird and bat fatalities were evaluated and compared for bird/bat detection rates and large events ($>$ 5 fatalities), species composition (over 200 post-construction fatality studies), and trends (EC inspection detection rates with published fatality rates).A key factor on validity of the methods is testing searcher efficiency. Bias trials of O&M personnel were conducted in 2010 to evaluate their detection of fatalities during EC inspections at four sites in the US. Detection levels were 76% (105 of 139). This reinforced the use of operations personnel.There were no large events, and there were low numbers of detections per search. More bats than birds were found during EC inspections than incidentals reflecting spatial occurrence of fatalities and their detectability. Species composition

of birds and bats was broadly similar to species composition from other wind plants. The overall seasonality of discoveries during turbine checks and incidental observations for overall species composition was broadly similar to national patterns. Detection rates from long-term monitoring were weakly correlated to comparison sites but there was a significant correlation ($p < .0001$) between the median number of bat fatalities found during EC inspections and fatality studies at similar plants. This suggests that detection rates for long-term monitoring may be useful as a broad index to overall fatality rates or detecting large fatality events. There was little evidence for trends in detection rates, and no evidence for increasing trends in detection rates. The assessment demonstrates that long-term monitoring using trained O&M personnel provides an indicator of wildlife impacts, presents a sensitivity to trigger responses, and is a valid approach for understanding impacts at operating assets. Examples of adaptive management and measures for European consideration will be presented.

Avian Power Line Interaction Committee: A Partnership Working for Avian Resources

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Abstract

The Avian Power Line Interaction Committee (APLIC) leads the North American electric utility industry in protecting avian resources while enhancing reliable energy delivery. APLIC works in partnership with utilities, resource agencies, and the public to:

- Develop and provide educational resources,
- Identify and fund research,
- Develop and provide cost-effective management options,
- Serve as the focal point for avian interaction utility issues, and
- Prepare comments on agency proposed rules and guidance.

The major benefits of APLIC membership include:

- Access to the network of fellow utility professionals sharing their experiences in addressing avian/power line issues such as collisions, electrocution, nests, and construction BMPs. APLIC members are at the forefront of managing the avian issue with peer-to-peer feedback and discussion.

- APLIC provides a forum for utilities to meet with state and federal agencies to discuss issues of common concern and work towards solutions. APLIC acts as the model for partnerships to address wildlife issues in a cooperative manner.

- APLIC members have opportunities to provide input when APLIC works with the Service to develop cost-effective implementation measures under the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, and Endangered Species Act.

APLIC provides a website (www.aplic.org) with numerous sources of information and resources including:

- Avian Protection Plan (APP) Guidelines developed in cooperation with the U.S. Fish & Wildlife Service

- *Suggested Practices for Avian Protection on Power Lines: State of the Art in 2006* (includes guidance on minimizing avian electrocutions on electric utility facilities as well as nest management options)

- *Reducing Avian Collisions with Power Lines: State of the Art in 2012* (includes guidance on minimizing avian collisions with power lines)

- *Sage-grouse BMPs: Best Management Practices for Electric Utilities in Sage-grouse Habitat* (identifies types of utility activities, potential impacts to sage-grouse or their habitat, and BMPs to minimize impacts)

- *Developing Power Pole Modification Agreements for Compensatory Eagle Mitigation for Wind Energy Projects*, intended to provide considerations and guidance for electric utilities, wind companies, and agencies working on power pole modification agreements for compensatory mitigation for eagle take at wind facilities.

APLIC holds a spring and fall business meeting in conjunction with a workshop instructing on avian/power line issues and solutions. APLIC also presents education and training sessions for federal and state agencies, wildlife professional organizations, and environmental NGOs.

Lost in bias? Multi-faceted discourses framing the communication of wind and wildlife research results – the PROGRESS case

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Abstract

In times of selective perceptions of research results, actors often claim a privileged interpretation of data and results. A recent example (set in Germany) is the agitated debate over a comprehensive study of the "Prognosis and assessment of collision risks of birds at wind turbines in northern Germany" (short: PROGRESS). The study's results created a kind of turmoil in the national community, with involved actors both in the wind energy sector and conservation community. PROGRESS conducted an extensive fatality search in the northern German lowland which is presently the hub of wind energy development in Germany. Moreover, population models were developed to quantify population effects, building on fatality estimators. PROGRESS shed a specific light on the common buzzard (*Buteo buteo*) – a raptor species, which has not been considered a wind energy sensitive species before – as the study estimates a population decline for both the endangered red kite (*Milvus milvus*) and the common buzzard. A controversial discourse flared up between conservationists, planners, and the wind industry questioning the validity of the arguments, the researchers' expertise, and likely consequences.

We exemplarily selected the PROGRESS discourse and identified stakeholders, their argumentation patterns and motives; thus, carrying out a '*frame analysis*' by assuming that discourses comprise different patterns of perception and interpretation, which can be systemized in a frame. This qualitative analysis was based on publicly available statements about PROGRESS, e.g. from agencies, associations, and the media.

Findings indicate that uncertainties still revolve around estimators, population models, the efficiency of mitigation measures, and whether one could handle the challenges at hand with a case-by-case approach or at a meta-level. The discourse shows that scientific results are interpreted differently, depending substantially on the circumstances and the motivation of the debaters. Some arguments were also identified as not verifiable, presumably due to their specific framing. Quantitatively, the frames '*conservation*' and '*scientific methods*' are of

importance in the discourse due to raising the question of whether wind energy development actually affects raptors at the population level. Additionally, issues have emerged concerning the upscaling of the legal term '*significantly increased fatality risk*' to population effects, emphasizing the need for adequate legal planning requirements. While some actors in the discourse arena, the *objectifiers*, perceive collisions as stochastic events and therefore question the study's relevance and transferability, others act as relativists by addressing alternative avian risk factors and question PROGRESS' extrapolated population effects. Other discussants either accept the population models and voice a need for adjusting conservation practices or question the researchers' integrity and call for yet stronger conservation standards.

In conclusion, the question became pressing how to derive planning recommendations from scientific results and who might unanimously communicate both recommendations and knowledge; hence, accentuating the awareness and focus required within the science-practice-interface (e.g. implications, reactions, interpretation).

Bird behavioural response to the surrounding environment:
A specific approach to wind farm location and placement

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Abstract

Wind Energy Facility operation requires the presence of rotating wind turbine blades, in addition to habitat alterations, e.g. caused by the construction of turbine platforms, road access or substations. Bird behaviour is closely related to the surrounding habitat, as it influences the hunting areas for many raptor species, or the nesting sites for ground nesting species, among others. Due wind farm presence, such behaviours may change by shifting to further locations; cease and have negative impacts on the local population ability to persist; or be attracted to the new features created increasing collision risk behaviours, particularly with regards to hunting and foraging behaviours. With this study, we aimed to evaluate bird behaviour change at wind farms in Portugal, both in accipitrids and falcons, but also in relation to flight behaviour, due to the presence of wind turbines.

Three wind farms with pre-construction and operational phase bird monitoring programs, in Northern, Central and Southern Portugal, were chosen for analysis. At each wind farm raptor species with frequently observed movements were selected, including Common Buzzard *Buteo buteo*, Black-chested Snake-Eagle *Circaetus gallicus*, Common Kestrel *Falco tinnunculus* and Montagu´s Harrier *Circus pygargus*. Spatial models were fitted for each species per project phase to determine altered spatial usage. Similarly, bird behaviour with regards to hunting, soaring, territorial and passage flight types was evaluated with regards to the different project phases. We constructed potential distribution models using maximum entropy (MaxEnt) techniques in software MaxEnt 3.3.3k, by combining observation records with environmental features (terrain aspect, slope, vegetation type).

With very rare exceptions bird species demonstrated an attraction effect to the wind turbine presence in operational phase monitoring programmes, when comparing to the models obtained in pre-construction phase: before wind turbines were placed, species presence was mostly determined by terrain aspect and vegetation type. However, in the operational phase, distance to wind turbines revealed a high contribution in determining presence probability

(∼70% on average). Bird behaviour type was also altered, with the same pattern being detected for passage, soaring and hunting flights. These are however preliminary results as refinement of the variables considered, will increase model adjustment.

The results demonstrate a clear influence of wind turbine presence in raptor activity at wind farms in Portugal. Such presence has resulted in an apparent attraction effect which might be related with the fatality levels of some of the species analysed, such as the Common Kestrel. The identification of variables with higher importance in raptor ecology and flight patterns will allow to implement adjusted mitigation and compensation measures. Such measures may include habitat management or terrain modifications, to divert birds from risk areas, with the objective to avoid wind turbine caused bird fatalities. In an adaptive management perspective, this analysis is highly important to understand the causes for wind farm's negative impacts, and propose adjusted measures to mitigate them. Also, future projects should be informed by these results with regards to prospective impacts on the existing bird community and proactive mitigation can be applied before operational phase.

Fatality estimation using the Bayesian approach: Prediction of fatalities and adjustment of monitoring programmes

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Abstract

Bird and bat fatalities are a major concern since wind farm operation started worldwide. Besides local impacts it is still unclear the cumulative regional and population-scale effects such fatalities have. The implementation of a working framework which allows to predict, with confidence levels, the extent of these fatalities and act accordingly may be the next step in wildlife-wind energy monitoring activities. In this study we intend to demonstrate the applicability of the methodology developed by Huso et al. 2015, in estimating future fatality trends, at wind farms in Portugal, using standard fatality monitoring methods.

We considered information from five wind farms located in Portugal, with robust operational phase monitoring information, including carcass searches and bias trials (carcass persistency and searcher efficiency). Five of these wind farms were surveyed for bird and bat carcasses with human observers, while one of them conducted searches with human-dog teams. Data was fed into the Evidence of Absence software (version 0.2.14), which applies the conceptual framework presented in Huso et al. (2015). Using the software, yearly fatality estimates were obtained per project and per faunal group. In addition a subset of the generated estimates were considered as prior information to estimate long-term fatality scenarios at the wind farms studied. Corresponding outputs (yearly estimates and predicted values) were correlated to determine prediction accuracy. Finally linear models were fitted to assess determining covariates responsible by model prediction accuracy.

Predicted fatalities were in general highly correlated with the yearly estimated fatality ($\rho > 0.8$). Predicted estimates were more accurate when using robust prior information, as per example with four years of carcass searches. The model did not perform as well with lower amounts of information ($\rho \sim 0.7$). Of note was the low model performance in predicting bat fatalities in a long term scenario ($\rho \sim 0.2$). Variables with a higher influence in the model prediction performance included the number of observed fatalities and the estimated detection probability ($\hat{g}$): the model underperformed in situations when: (i) the number of observed

fatalities in the "future" years was higher than the years used as prior information, and/or (ii) the estimated detection probability ($\hat{g}$) was low.

As concluding remarks our analysis indicates that:

1. Even using standard methodologies, having a high detection probability and robust prior information, prediction of potential fatalities in a long-term scenario is a possibility at wind farms in Portugal. Notice though that the utilization of additional effort and above the standard methodologies (such as human-dog team utilization) produce more accurate results, with particular relevance for bat fatality estimation.

2. This tool allows to determine the necessity of further mitigation if a high number of fatalities are expected or a reduced fatality monitoring effort if the wind farm does not represent danger to the local bird and bat communities.

3. However a potential limitation of this tool is its underperformance in situations not represented in the prior information (e.g. fatality temporal hotspots/ variation in fatality temporal patterns).

Local stakeholders' involvement on offset/compensation projects: What is their role and how they matter for sustainability?

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Abstract

The investment in wind energy represents substantial reduction of carbon emissions, contributing to act against climate change. However, wind farms are not free of impacts on biodiversity – negative effects include mortality of birds due to collision with turbines. Due to their ecological traits, raptors and other soaring birds are among the most affected species, and fatalities may represent significant impacts when dealing with endangered species. To reduce the potential and real impacts, wind development projects should follow the "mitigation hierarchy", a sequence of processes and actions to (1) avoid, (2) reduce/minimize and as last resort (3) offset/compensate any residual impacts.

Offset/compensation measures resulting from collaborative approach between regulators, developers and other stakeholders have been implemented in Portugal in the last 10 years, on wind farms and power lines, following similar strategies for both project types. Here, the main approach usually focuses on habitat management techniques to improve habitat conditions outside the affected area but, if possible, in neighbouring areas and to discourage the usage of the project area. The aim is to promote endangered species' breeding success and/or enhancement of their foraging habitats, contributing simultaneously to compensate for habitat deterioration and minimize collision risk. Offset/compensation basis scheme is designed in the early stages of development, according to the characteristics of the study area and the ecological requirements of the target species, and include monitoring schemes to assess biodiversity gains and losses throughout the programmes' lifetime.

Since these programmes rely mainly on conservation-type measures, one of the major components is to achieve local communities' support. We consider that ensuring the engagement of local populations on offset/compensation programmes is a crucial approach to achieve success. Cooperation with local stakeholders by sharing knowledge and increasing environmental awareness is the only method that leads to the sustainability of the programmes on the medium-long term.

In this presentation, we do a reckoning of the local stakeholders´ involvement, their role according to different types of offset goals (habitat management) and endangered species. Also, a balance of the outputs of the point-of-view of local stakeholders by the end of the first phases of compensation programmes is made. Since 2007, we have implemented 6 offset/compensation programmes (total of wind farms and power lines) from North to South of Portugal, with a duration from 3 to 5 years, and established cooperation protocols with 26 local stakeholders, in different projects. These include mainly hunting managers (12; 46%), since some of the most representative prey species for several raptor and scavenger target species (e.g. *Aquila chrysaetos*, *Aquila fasciata*, *Neophron percnopterus*) are European rabbits and red-legged-partridges. These species have also an important socioeconomic role in hunting areas, so increasing its populations represents a win-win situation. Also, local shepherds (5; 19%) arise as relevant in cooperation's, since the promotion of extensive grazing (by providing pastures and ponds to cattle), a declining traditional procedure in Portugal, has an important role to promote feeding habitat to birds that have preference for open lands (e.g. *Circus pygargus*, *Pyrrhocorax pyrrhocorax*, *Falco tinnunculus*).

Automatic Bird Identification and Strike Assessment System for Offshore Wind Farms

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Abstract

Suomen Hyötytuuli Oy is constructing an offshore wind farm on the Finnish west coast. The minimal demand in their environmental license defines that species in the turbine area are monitored and possible collisions prevented concerning especially two species: White-tailed Eagle, *Haliaeetus albicilla* and Lesser Black-backed Gull, *Larus fuscus fuscus*. Until now, no reliable way to measure nor even estimate the number of strikes has been available. In cooperation with the company and Tampere University of Technology a prototype system for identification of flying bird species is developed.

Our main research questions are:

- How to identify automatically the target bird species at the vicinity of the wind turbines?
- How many bird strikes really occur at the study area?

Indubitably, a radar is the obvious choice to detect and identify the birds. However, consulting with radar suppliers revealed that the identification capacity is limited to five size classes only and they made evident that it is not possible to classify bird species any further merely by radar. The main reason for this is that variation between the same object in a different section in the radar beam (and in a different position as well) is larger than variation between two different objects. External information is required and a conceivable method is to exploit visual camera images. The prototype system operates by a SLR camera and a 500mm tele lens. The system includes our software for controlling the camera and steering a motorized video head.

The bird species identification is based on a fusion of radar data and image data. The radar locks on a target bird and provides the coordinates to the camera steering software. The camera steering system tracks the flying bird enabling to obtain series of images. The data provided by the radar to the identification algorithm consists of velocity, bearing, elevation and the trajectory of the target. The images obtained by the camera system provide data of color and shape. The size estimate of the target is calculated. A deep learning algorithm

of the convolution neural network accomplishes the classification of bird species according to their shape and coloration. The final identification is the result from a combination of the classification and the radar data. A collision with a wind turbine and an identified bird species is discoverable by radar tracking data and the final identification.

We present the identification capability of the deep learning algorithm and preliminary results of the following:

- Number of successfully tracked birds of the steering system;
- Number of correctly identified species of the whole system;
- The identification is verified manually;
- Number of discovered collisions;

Currently the only way to deter bird collisions is to shut down the wind turbine in question.

A study of how different bird species behave near turbines and how to avoid or prevent the strikes is the next phase as well as a concept level automatic strike prevention system.

Expansion of WREN – An International Collaborative Under International Energy Agency Wind

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Abstract

Land-based and offshore wind energy projects must address concerns of environmental effects if project permits are to be secured. While deployment thresholds have been established in many countries, access to information on efficient monitoring programs and effective mitigation strategies has been problematic. To address this challenge at an international level, the International Energy Agency (IEA) Wind supports Task 34, known as WREN (working together to resolve environmental effects of wind energy). Current members include Canada, France, Ireland, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and the United States. The objective of WREN is to facilitate international collaboration that advances the global understanding of environmental effects of land-based and offshore wind energy development. WREN is a shared global knowledge base and community of practice around research, monitoring and management of the environmental effects of wind energy development.

WREN was initiated in 2012. Its first phase was a four-year period, ending September 30, 2016. Country membership and interest in WREN has grown since inception, and as a result a proposal extension was submitted and approved by the IEA Wind Executive Committee in 2016. This extension allows WREN to continue through September 2020. During Phase 1, two key products were developed: 1) WREN Hub, a database platform where all WREN-related information is located and 2) a white paper focused on adaptive management.

This poster will inform the audience about the activities that are planned during Phase 2 of WREN. One activity is the development and wide spread distribution of white papers on the following topics: cumulative impacts; green verses green (balancing the local effects of a wind facility on sensitive species against its global benefits such as CO2 emission reduction); environmental risk-based management; and, a paper that describes the interrelationship of all the WREN white paper topics. This last paper will include the adaptive management white

paper (published in November 2016) and a manuscript focused on considering individual effects of wind energy development and how this relates to population-level impacts on wildlife (submitted to a journal in January 2017). Other Phase 2 WREN efforts focus on the continued development and enhancement of WREN Hub (https://tethys.pnnl.gov/about-wren), a dedicated, publicly available, centralized knowledge management system providing easy access to existing information pertaining to wind-wildlife issues for both offshore and land-based wind energy, and numerous outreach and engagement activities. All these activities are aimed at contributing to supporting the expansion of land-based and offshore wind energy deployment.

The SKARV System - Preventing bird strikes through active control of wind turbines

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Abstract

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1. Objective

The potential for collisions between birds and wind turbines may in some cases be costly for wind power plant developers. First, obtaining permits for construction may be difficult or impossible if a sensitive species is discovered at a potential site. Worse is the case where a problem is discovered after construction or operation has begun. This can lead to enforced curtailment of production, and requirements for extensive monitoring of the impacted species´ presence, behavior, and mortality at the site.

The objective is to develop a wind turbine control system that minimizes the probability for birds and blades to be located in the same place at the same time.

2. Methodology

The idea is that a wind turbine is outfitted with a number of sensors (visual, infrared, radar) capable of detecting and tracking approaching objects. The tracking problem is not an easy one, but recent developments in technology – like ball and puck tracking in professional sports, automotive laser and radar systems, and remote sensing systems in consumer products like the Xbox Kinect – place it within the realm of reason. Tracking one or more birds, an optimization problem is continually solved to find the blade azimuthal position that minimizes the probability of collision. The rotor speed is perturbed, either accelerated or decelerated, by a small amount to attempt to place the blades at the desired location at the critical moment.

3. Results

The results of a preliminary simulation study, undertaken to demonstrate the concept and characterize the sensor requirements, will be presented. Initial investigations into sensors and tracking algorithms will also be addressed.

Evidence of nightjar disturbance distances during construction works at an upland wind farm site

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Abstract

The European nightjar is a ground nesting bird that is almost exclusively associated with commercial forestry in Wales. Areas of commercial forestry have been identified by policy (TAN 8) for large scale wind development, where they have the potential to impact upon important nightjar populations. Pen y Cymoedd Wind Farm (South Wales) is the largest onshore wind farm in England & Wales, comprising of 76 turbines. It is also home to an important population of nightjar. In order to minimise the risk of impacting upon this species a mitigation strategy was agreed with consultees, which included a combination of avoidance and the implementation of a 200 m no works exclusion zone around any nest site. This 200m exclusion distance is based on limited evidence from studies on the active disturbance response of the species to recreational human activities (i.e. dog walking, ringing etc) and as such may be of little relevance to construction works. During nightjar surveys in 2014, 2015 and 2016 active nightjar nest sites were located within 200 m of proposed works areas providing an opportunity to review this disturbance distances during construction phase works. Works in close proximity (<200m) to all nests were completed under a constant watching brief utilising a variety of monitoring methods (i.e. Radio tag, remote camera, visual observation) as appropriate to the nest site location. No evidence of active disturbance was noted at any monitored nest site in any year. We conclude on the basis of this evidence that current best practice no works distance recommendations are likely to be overly cautious and not cost effective.

Monitoring nocturnal bird migration on a regional scale using operational weather radars

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Abstract

Wind energy is increasingly becoming a preferred source of clean renewable energy. However, wind farms also have a negative impact on the environment, such as the occurrence of collisions of birds with turbines, blades, and associated structures. Especially during migration, when in a limited time period high densities of birds move through specific areas, the risk of collisions is greater. To reduce the collision risk during such events, a good understanding of the spatial and temporal dynamics of bird migration is required. Operational weather radars are a successfully applied method to monitor bird migration, where migration characteristics, such as bird density, flight altitude, and migration speed and direction are deduced from the radar data via a bird detection algorithm. In Europe, studies have been limited to a single or a few radar sites and predictive migration models have been developed to reduce the impact of birds on military aviation safety. We developed a proof of concept in which we test the applicability of an existing bird detection algorithm on the European weather radar network, allowing to study bird migration dynamics on regional scales. To investigate spatial and temporal migration dynamics, we used radar data of 17 C-band radars in France and calculated bird density (birds/km2), flight altitude (km above ground level), and mean ground speed (m/s) and flight direction (° from north) per night across all latitude bands. We found that the application of the bird detection algorithm gave consistent results, and that densities and altitudinal distributions were consistent with those found in previous studies. This proof of concept shows that procedures so far applied to a single radar site can be scaled up to the regional and likely continental level. Being able to study bird migration at such scales will allow us to better understand its characteristics and dynamics, and opens up the possibilities to study influence of weather and geography. A better understanding of the migration dynamics will enhance our predictions of the spatial and temporal occurrence of high bird densities and

flight altitudes, so that appropriate measurements to minimise the risk of collisions with wind turbines can be taken.

Wind farms in Croatia - An overview of impacts, procedures and issues

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Abstract

Since 2004, 18 wind farms (600 MW) have been built in Croatia, and 22 are in the process of issuing building permits. All existing and planned wind farms are located in Dinaric part of Croatia, which has the best wind energy potential. But, among many other bird species, Dinaric part of Croatia is also the area of distribution of the critically endangered golden eagle (*Aquila chrysaetos*) (25-30 breeding pairs) and endangered short-toed snake eagle (*Circaetus gallicus*) (110 – 140 breeding pairs), that are especially prone to collisions with wind turbines due to their ecology, which can have significant negative impact to their small populations. Furthermore, since this is karst area characterized by underground pits and caves, it is an important habitat for many wintering, breeding and migration colonies of bats. Also, Dinaric part of Croatia is a home to three big carnivores – wolf, bear and lynx.

In Croatia, before obtaining the building permit, each wind farm has to undergo procedures of environmental impact assessment (EIA) and Natura 2000 appropriate assessment (AA). It is worth mentioning that Natura 2000 covers 36.73% of the continental territory and 15.42% of the marine territory of Croatia. In Croatia, EIA studies are prepared by certified firms and committee of experts and government representatives gives an opinion on the study. Public consultation is also a part of the process. In procedures where AA is carried out, CAEN gives an opinion on the study. For the purpose of the EIA study, research is usually carried out for birds and bats. Only in recent time, EIA and AA studies have started to conduct evaluation for large carnivores. In order to improve assessment for large carnivores, Veterinary Faculty in Zagreb and CAEN have developed manual for assessment of wind farm´s impacts on large carnivores, based on habitat sensitivity map.

The main problem regarding assessments is the quality of the studies. Although in 2010 the Ministry of Environment and Energy prepared guidelines for assessment of impacts on bats and birds in regard to wind farms, these guidelines give only basic research methodology for bats, and therefore should be improved and adapted for Croatia, especially Mediterranean region, based on Eurobats guidelines. In Croatia, only one EIA for wind farm was rejected

(Fužine I) due to evident negative impacts on environment and nature, as well as objections of the local community. Another wind farm (Mideno brdo) was rejected during the process of AA, as it was planned 1.1 km from the cave where large colonies of Natura 2000 target bats species breed and gather during migration. Wind farm Bila ploca received environmental permission, but an NGO filed an appeal objecting the inadequate field methodology and usage of old data as the basis for assessment of the impact on birds. Planned wind farm was located within the home range of the golden eagle and it was not in accordance with the spatial plan, so the permit was rejected on the Croatian court.

Mapping and modelling seabird distribution in the taiwan strait to support spatial planning of offshore wind farms

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Abstract

Wind power is flourishing in Asia. Given the dense human population in Southeast Asia, many wind farms in the region are planned offshore. Yet hardly any background ecological information about this marine environment is known.

The Taiwan Strait is one of the most wind-rich areas in the world, and developing offshore wind energy has been set as a main policy by the government. In 2016, we conducted over 60 boat surveys in northeastern Taiwan Strait and documented the location, species and flight height of seabirds. Distance-corrected density was calculated for each species. Preliminary spatial models were further conducted to predict the distribution of seabirds. The results revealed major hotspots for seabird activities, which indicated potential high-risk sites for wind energy development. We overlaid the results with wind farm locations proposed by the Bureau of Energy and discussed the potential impact.

Invasive plant control - Challenges and opportunities

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Abstract

Invasive plant species are nowadays a conservation issue and are considered one of major threats to biodiversity. Habitat disturbance that take place during wind farm construction can promote the spread of invasive species, mainly along wind farm structure and from there to natural surrounding areas, where high conservation values usually occur. As so, invasive species represents one of the major treats for biodiversity in this areas and it is necessary to access the appropriate methods to minimize the impact, and if necessary, to implement control programs.

Control of invasive plants faces many challenges and in the last years we have been working to better address this and promote effective ways to solve them. This work has the purpose to discuss some of this challenges, as well as the opportunities, contributing to the success of the plans and its further implementation. To accomplish this, we have done a critical review of all the work performed in several wind farms in the past 10 years.

We found that something critical to the success of plant control plans was the capacity to be adapted. Control plans implementation might be dynamic and its framework should address that since the planning stage.

Challenge was also setting the main goal of the control plans. Initially the aim was established as the eradication of invasive species from the areas but soon we realized that this was an unrealistic target. As so, we needed to adapt the objectives to something that would be achieved. Quickly we identified that control would be the best target.

Challenges were also identified with field work issues as data collecting, timing and quality of control actions, external interferences or invasive species resistance.

Above all, it is difficult to know when we get the control or which is the threshold to this. A line must be drawn between what is the project impact and what is the process of biological invasion in a specific region, since projects location are not limited or isolated sites and there are constant exchanges with the surrounding environment as well as interference from other activities.

This takes us to the opportunities, such as the identification of guidelines for minimization measures that might be implemented to constrain invasive species proliferation during construction works.

Control plans are also an opportunity to engage populations and civil society groups, local companies, ONGs and experts, working alongside not only to promote cleaner energy but also to protect biodiversity and the ecosystem from long lasting changes caused by invasive species.

Wind farms aren't the same concept to all of us? So what are they?

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Abstract

In 2016, the Portuguese production of electricity was led by renewable sources that granted 58% of the national consumption, 42% came from fossil origin and 10% of the production was exported to Spain (APREN, 2017). Wind energy alone contributed with 24% of the national consumption. The impact of renewable energy on the Portuguese economy is significant and well known. APREN and Deloitte (2014) have demonstrated that the renewable energy sector is gaining a growing importance in Portugal giving an important contribution towards the country's sustainable development, economic growth and employment creation. As an example of the significant impact, in 2013 the renewable energy sector contribution (directly and indirectly) to the Portuguese GDP was 2.730 millions of euros and it is expected to be of 3.800 millions of euros in 2020 (APREN and Deloitte, 2014). Also the savings from CO2 emissions licenses was 47 million of euros in 2013 and it is expected do reach 187 million of euros in 2020. One of the technologies with great impact on the renewable energy sector is Wind. Although it is undoubtable that the renewable sector and specially the wind energy can contribute positively for the macroeconomy of Portugal it is not exempt from controversy, specially the relation between wind industry and wildlife.

The positive and negative impacts of the wind farms have been analysed over more than 100 hundred EIA process were the focus was on looking for technical answers (impact identification) on different section that compose a EIA (different impact receptors). Probably one of the most controversy section is the one related with wildlife. The approach on the execution of an EIA process is assumed as logical and rational devaluing the importance of values and beliefs that each stakeholders has about the theme. Stakeholders have different beliefs and expectations that migth lead to a conflict. To explore these we have interview different stakeholders (developers, national authorities, specialists, civil society representatives) in order to present a wide perspective of how the Portuguese society percepts the wind industry. All the information collected have been analysed and different patterns and connections have been identified. As a result we where able to identified what is in the opinion of the different

stakeholders, what they consider is working and what is not working on the EIA process. To increase the consensus about this industry and hopefully contribute to the development of a better environment a number of actions have been idenified. We strongly believe that our findings will contribute for best practices development, specially in countries where this industry is emerging.

APREN and Deloitte, 2014. Macroeconomic impact of the renewable electricity sector in Portugal.

APREN, 2017. Boletim das energias renováveis dezembro 2016.

Effectiveness of mitigation measures to avoid fatalities in the populations of lesser kestrel (*Falco naumanni*) at wind farms in Central-East Spain

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Abstract

Central-east Spain is characterized as a flat and relatively open, highly agricultural-used landscape with a high density of wind facilities. This landscape also hosts a great population of lesser kestrel (*Falco naumanni*), one of the most threatened species by windmill-collision in Spain.

We analysed bird mortality records, during a ten year period 2005-2014, within 133 turbines in three wind farms: Cerro del Palo, Cerro Calderón and La Muela I, located in Cuenca province (Spain). The subject was to determine variables associated with the mortalities caused by turbines. Based on this information, a mitigation measuring has been implemented. It consisted of superficially tilled the base of the turbines with more collision with birds, in order to avoid, or minimise collisions. This measure was monitored during 2015-2016 in order to compare its effectiveness between tilled and non-tilled turbines and collision frequency on birds.

This measure is based on reducing the attraction of birds to these tilled areas, because limiting vegetation reduces the abundance of potential prey, manly Orthoptera. The lack of prey in all tilled turbines could be responsible for the decreasing incident of the kestrels, since they must look for prey in other areas out of the dangerous turbines (around a maximum of 80 m).

After monitoring the mitigation measure, tilled the periphery of the turbines has reduced collisions with lesser kestrels between 75 and 100%. In fact, in all wind turbines with active mitigation measures there has been no collision registered in the last two years. Due to these results, this mitigation easy and inexpensive measure is very effective to reduce significantly collisions with insectivorous raptors.

How to reduce uncertainty using a questions based approach for universal wind energy assessment

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Abstract

When we conduct due diligence for wind energy projects internationally it is apparent that there are a variety of methodologies used for assessing impacts of projects to wildlife. Our approach for overcoming variation in methodologies used or recommended in published guidance is to employ a questions-based framework approach.

Our questions-based framework is hierarchal and tiered on principal questions which aim to identify what the key risks are. Step 1 - identify the principal questions (e.g. was bird use and species composition at the project evaluated; do the results suggest risk to vulnerable and/or species of conservation concern). Step 2 - assess whether the methods used were in conformance to published statutory guidance (e.g. Portuguese Environmental Agency 2010), or whether methods met industry "good practice" (e.g. Strickland et al 2011). Step 3 - assess the scope of the studies and whether they were of sufficient rigor to address the principal questions. It is at this stage where it is easy to become distracted from key risk assessment questions, and focus on nuances (e.g. study design, sample selection). Step 4 - the results are assessed in respect to assessing critical issues and significant impacts. For example, was a legally protected species identified and do the results suggest a high level of risk? Legal drivers, as well as precedent, are pivotal considerations. E.g. in some countries vulnerable wildlife such as bats may not be afforded equal protection to less vulnerable but more charismatic wildlife, or there may be a lack of precedent in evaluating those species.

While our questions based framework may seem intuitive, the recent National Wind Coordinating Collaborative workshop on International Exchange on Wind Energy and Wildlife (2016) illustrated that in many countries diverse and often inappropriate methods are still commonly used, and the audience debated which approaches are appropriate for evaluating impacts. There is value in seeking a common framework to minimize erroneous method selection as well as to provide a universal context for evaluating projects. Our questions-based framework approach has been successful for due diligence and may be applied more universally.

We will present several key questions and examples of when appropriate and inappropriate methods have been used (e.g. the use of spotlight surveys to assess bat collision risk). We will review how guidance from mature (USA, UK and Portugal), growing (Ireland), and developing markets (World Bank Guidance and South Africa) vary in respect to methodologies, but how they also share common ground in respect to assessing projects when seen in the context of a questions-based approach.

Rather than qualify specific methods, we seek to encourage thought and discussion, particularly among participants from countries where limited wind energy development has occurred. We will discuss the benefit of sharing data and propose avenues to achieve this, which we see as critical for reducing uncertainty in project evaluation, progressing the knowledge base, and minimizing project costs. If compatible with CWW, we will accompany our talk with an interactive poll for the audience on principal questions and appropriate methods.

"Birds in space" - A review of methods to assess the use of the airspace by birds: Implications for evaluating the impacts of wind energy generation

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Abstract

Habitat use is a unifying concept that permeates many aspects of ecology and biology. It has both theoretical and applied use, in disciplines from behavioural ecology to evolutionary adaptability. The aerial environment is a dynamic and highly varied habitat, upon which diverse organisms, from birds to bats to insects, are dependent. The multi-dimensional variability of the aerial habitat, or aerosphere, has consequences for the spatial habitat use of airborne organisms and subsequent understanding of the behavioural processes behind their distribution and abundance. Understanding where and when passage and resident birds use this habitat is increasingly relevant with the rapid development of wind energy. Wind energy structures have the potential to change the aerial environment directly and alter substrate characteristics, thereby changing the features of surrounding airflows. However, there is a lack of information regarding the characterisation of the aerial environment in terms of bird flight, and how variability in the aerial environment affects flight behaviour on a local scale.

Space use and associated behavioural flight characteristics of birds are integral components in modelling approaches to estimate avian mortality due to collision with wind turbines and associated infrastructure. Flight height has received considerable attention when assessing avian interactions with wind farms and it is frequently the only flight characteristic considered when assessing vulnerability to collision. Notwithstanding the relevance and challenges associated with assessing flight height, relatively little consideration has been given to other flight characteristics associated with a given flight behaviour. Yet recent technological advances in tracking techniques have provided us with the potential to measure and analyse a suite of flight characteristics, such as flight speed and trajectory, with some technologies able to spatially and temporally place flight in the context of surrounding airflows.

Here we review the methods for investigating bird flight characteristics, including bird-borne telemetry, radar, laser rangefinders. We acknowledge that investigation of a diverse suite of flight characteristics may not result in a singular suitable method, but rather that each technology should be considered within the context of the precise questions being asked. We will therefore provide an overview of the pros and cons of each technology, considering the deployment situation and the flight characteristics of interest. We suspect that some approaches may offer more value as preliminary or supplementary methodologies and combining approaches will lead to the most comprehensive assessment. We look forward to the advancement and development of future technologies in improving our understanding of the variation in flight behaviours and characteristics.

Study of the effect of the design and implementation of the Dos Pueblos Wind Farm on the habitat and populations of Dupont's lark

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Abstract

The installation of the Dos Pueblos Wind Farm, within the municipal boundaries of Miedes de Atienza and Bañuelos in the province of Guadalajara (Spain), has been carried out in a way that has the least possible effect on the habitat of Dupont's lark in the areas adjacent to the wind farm. With this in mind, in 2006, an environmental suitability and population study was conducted in order to reveal the status and distribution of Dupont's lark in the wind farm installation area. A methodology was developed to evaluate the compatibility between the construction and operation of the wind farm and the conservation of the populations of Dupont's lark in order to design the park in accordance with the environmental determinants established by the suitability study.

While the park was operational and during the 8 years of sampling (from 2008 to 2015), it was determined that the evolution of the population of Dupont's lark had followed a number of trends. It was concluded that the species had remained in the area and that, in principle, no effect was observed on the populations or their habitats after the construction and commissioning of the wind farm.

Regarding possible collisions with the wind turbines, a priori, the presence of the wind farm does not significantly affect the behaviour of the lark since it spends most of its time on the ground, walking or making short flights that do not tend to take it more than 3 to 5 metres from the ground, which means that the risk of collision is very low or non-existent. During the breeding season it makes mating flights, which are very rare during the day but more frequent at night. The flights observed during the day tend not to last more than 5 to 10 seconds and rarely reach a height of 30 metres, which is the distance from the ground to the ends of the wind turbine blades.

In conclusion, the data obtained seemed to indicate that the environmental suitability studies made in the pre-operational stage can be an effective tool when designing wind farms to minimise their effects on Dupont's lark. Placing the park infrastructure on the periphery of

the distribution areas of this species seems to be an appropriate solution. It leaves the areas of greater density free and the patches with a greater surface area continue to be a potential habitat, since the occupation of small breeding areas or potential habitats for Dupont's lark do not have any significant effects on the species, as long as the individuals have a sufficient alternative area.

Why are large gulls attracted to offshore wind farms?

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Abstract

Large gull species such as lesser black-backed and great black-backed gull were found in increased numbers in and around offshore wind farms in Belgian marine waters. This has raised concern on the number of expected collision victims, and considering the upcoming large scale exploitation of offshore wind in the North Sea, collision mortality might even affect these species on a population level. Up until now, however, there is little information on the behaviour of large gulls inside offshore wind farm areas, and it remains unclear whether these birds visit the wind farms because of enhanced foraging conditions or simply for roosting. Gaining more insight in this matter is considered crucial for a reliable collision risk assessment.

Since 2008 we have been studying seabird occurrence and distribution in and around the Thorntonbank offshore wind farm, located 25 km off the Belgian coast. In this wind farm, roosting possibilities are particularly numerous as 48 out of 54 turbines are built on jacket foundations which, during low tide, also offer easy access to the intertidal fouling communities.

In order to unravel part of the remaining knowledge gaps, we studied the occurrence and behaviour of large gull species in the Thorntonbank wind farm area using dedicated ship-based transect counts, GPS tracking data and observations with a fixed camera located on one of the turbines. First results show that the time spent on resting is much higher inside compared to outside the wind farm. Gulls were particularly attracted to the outer turbines, with significantly lower numbers occurring on inner turbines, suggesting a partial barrier effect. Turbine foundations were mainly used for roosting, and only during a short time period around low tide, small numbers of birds were observed while foraging on mussels growing on the lower reaches of the foundations.

The results of this study shed new light on the currently expected collision risk of large gulls at offshore wind farms, and highlight the need for proper post-construction monitoring. Pre-construction studies for example tend to extrapolate past and/or current numbers and behaviour to feed collision risk models. But next to a possible post-construction change in

numbers, the observed behavioural shift (i.e. decrease in time flying) will have a strong effect on the collision mortality among large gulls.

Key considerations for using modern radar systems for bird studies of wind energy projects

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Abstract

Radar technology has been used in ornithological research and ecological studies for decades, but despite a wealth of expertise in this field, there are no clear guidelines on the use of avian radar for on or offshore wind farm developments. The concept of using avian radar as a tool in the wind farm planning process (e.g. through an Environmental Impact Assessment), or for post-construction monitoring, is poorly understood amongst stakeholders. Often both the benefits and limitations of avian radar technology need to be evaluated on a site-specific level. There is a lot of confusion around what avian radar actually is, what data it can collect and, most importantly, whether the radar data can be translated into practical information and advice for decision makers. Recent advances in avian radar technology are rarely publicised, and the detection and tracking capabilities of newly available radar systems remain relatively unknown within the wind farm industry. Our presentation will provide a rationale for using dedicated avian radar systems for pre- and post-construction radar studies at wind farms to ensure a high standard of data acquisition processes and resulting outputs suitable for addressing the study objectives. We will provide an overview of key operational capabilities of modern avian radar system including: automatic tracking, cohesive sampling protocol, data streaming and archiving, and data integration and fusion. Depending on the information needed to address specific objectives, for example, the rate of movement of birds through wind farm (flux) or levels of macro-, miso- and micro-avoidance behaviour by migrating birds, different types of radar can be used for bird monitoring. We will compare the most commonly used radar systems: surveillance pulse compression radars and frequency-modulated continuous-wave (FMCW) tracking radars. Critically, we will provide guidance on the capacity of each radar type to address the key objectives for wind project assessment and monitoring studies.

Potential effects of North Sea wind regimes on *Nathusius pipistrelle* migration strategies to the UK and implications for offshore wind energy

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Abstract

Nathusius pipistrelle is a known migratory bat species within Europe with a predominantly NE to SW seasonal movement in the autumn and SW to NE movement in the spring. This movement has been well documented through ringing studies in a number of European countries (e.g. Hutterer et al 2005). However, the extent of this migratory movement to the UK and the status of *P. nathusii* in the UK has been unclear until recently. Research on this species through both national and regional studies in the UK since the late 90's has identified a small number of maternity roosts in East Anglia and Northern Ireland, a wide distribution of male advertisement roosts and a significant number of individual records. This evidence of presence in the UK has also recently been supplemented with robust evidence of migratory movements from Europe to the UK and vice versa through both detector surveys on ferries and coastal locations (BSG 2013 & 2014) and the capture/ re-capture of marked individuals (See http://www.bbc.co.uk/nature/25759149). As such it is increasingly clear that *P. nathusii* is a likely breeding, migratory and over wintering species in the UK with a proportion of the population migrating from mainland Europe to overwinter and mate before returning to maternity roosts on the mainland in the spring. This seasonal movement of bats thus must involve crossing of the North Sea. Two potential routes have been hypothesised in literature; 1. Netherlands/Belgium to SE England; 2. SW Norway to Eastern Scotland/NE England. Little is known of the potential migratory routes or the timing of movements taken by *P. nathusii* on either. The influence of weather including wind strength and direction on migratory strategies and behaviour is also poorly understood. However, it is likely that *P. nathusii* would seek to optimise its migratory strategy to minimise energy expenditure and thus seek to utilise the most favourable weather crossing windows in the spring and autumn period and most favourable routes.

In this poster we examine the known bioenergetics of migratory movements and flight costs of *P. nathusii* (Hedenstrom 2009) along with historical wind speed and direction data from

potential migratory route areas to identify suitable migration windows and potential corridors or possible suitable routes. We also explore the potential effects of these factors on migration behaviour and timing and implications in relation to potential mitigation requirements for offshore wind energy which is rapidly increasing in deployment within the southern North Sea.

Do birds in flight respond to (ultra)violet lighting? A pilot study

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Abstract

Concerns for bird collisions with wind turbines affect the development of onshore and offshore wind-power plants. To avoid delays in consenting processes and to streamline the construction and operation phase, functional mitigation measures are required which efficiently reduces bird mortality. Vision is the primary sensory system in birds, which for a number of species also includes the ultraviolet spectrum. Many bird species that are known to collide with offshore wind turbines are sensitive in the violet or ultraviolet spectrum. For species that are mainly active at lower ambient light levels, lighting may deter birds from the lit area. Utilizing (ultra)violet lights may in addition not disturb humans. We tested the efficacy of two types of lights within the violet (400 nm) and ultraviolet (365 nm) spectrum to deter birds from the lit area. These lights were placed vertically and monitored continuously between dusk and dawn using an avian radar system. Relative to control nights, bird flight activity (abundance) was 27% lower when the ultraviolet light was on. For violet light, a vertical displacement was seen, increasing the average flight altitude by 7 m in addition to a 12% decrease in overall abundance. This effect persisted over the season below 40 m above sea level. Although the results from this pilot study are promising, we argue there still is a long way to go before a potentially functional design to mitigate collisions that has proven to be effective *in-situ* may be in place.

Minimizing the trade-off between energy production and avian collision risk: A spatio-temporal model for optimal operational shutdown of wind turbines

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Abstract

Most proposed mitigation measures for bird collisions in wind parks focuses on adjusting operation by altering turbine speed (cut-in speed, feathering, shutdown on demand). Collisions can in this way be reduced by changing the operational regime, at specific turbines and certain wind speeds, or at high-risk situations in time and space. Such mitigation approaches have been successfully implemented for bats, as well as at sites within bird migration corridors.

However, these techniques will be more difficult to implement for breeding or resident bird species as they are utilizing the wind-power plant area continuously, with collision risk more evenly distributed in time. Nevertheless, selective shutdown may be done when specific turbines and timeframes or conditions with increased collision risk can be identified, and may involve scheduled maintenance. Previous studies have shown that aerial bird activity drops at wind-speeds above 8 m/s, where power output is especially high. It may therefore be possible to reduce the risk window at a relatively low cost because energy generation at low wind speed is limited while bird activity is high: the distribution of collision risk and energy production is likely to be different with respect to wind speed.

We developed a model to assess collision risk in space and time, as part of the Research & Development project INnovative mitigation Tools for Avian Conflicts with wind Turbines (INTACT). The aim was to investigate options to adjust operation regimes to reduce collisions, including a quantification of the potential loss in power production. Based on a long-term avian radar time series at the Norwegian Smøla wind-power plant (2008-2016), coupled with recorded collisions as well as wind and energy production data, we developed a generic optimization methodology to balance collision risk and production costs. From the avian radar data, we quantified the expected collision risk based on the Tucker (1996) model adjusted for approach angle. We made an interactive web-based interface to visualize the model, where the user can evaluate in space and time the relationships between avian collision risk, power

production and wind speed. That is, to help find acceptable solutions to the trade-off between maximising energy production and minimizing bird mortality.

When you see nothing at all – Displacement of seabirds caused by offshore wind farms?

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Abstract

The number of offshore wind farms in European waters has increased rapidly over the last years. Currently, there are 11 offshore wind farms operating in the German North Sea alone, and more are planned or already under construction. Concerns about impacts on marine wildlife, particularly on seabirds, have risen, one of them being the displacement of the birds due to disturbance from operating turbines and associated ship and helicopter traffic, leading to habitat loss. In Germany, wind energy companies have the obligation to monitor their wind farm area and a given surrounding area before, during and after construction for several years. Monitoring data of all German offshore wind farms are harmonized and merged in one database. This database allows for a large-scale analysis of wind farm effects across all wind farm areas in the German Bight.

The aim of our analyses was to determine species-specific reactions of seabirds in operating wind farm areas. Therefore, we analysed post-construction monitoring data (digital aerial surveys), collected within the framework of the statutory environmental impact studies issued by the German Federal Maritime and Hydrographic Agency. First analyses revealed that level of avoidance of the wind farm areas is clearly depending on species. Several seabird species showed strong avoidance of wind farm areas: numbers of red-throated divers and common guillemots are significantly reduced within and close to wind farm sites, whereas other species seem to be less affected.

Bat nightly and seasonal activity patterns at height: A cross country comparison and insights into conservation

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Abstract

During wind farm impact studies and monitoring, determining bat activity, their patterns and relation with the environment is an important issue. It allows predicting how the project will interfere with the bat community and help prevent impacts, especially if analysing data from bat activity at rotor height in case of wind farm projects. Studies from different countries have focused attention on documenting these patterns for a certain species at a given location. To the best of our knowledge, however, a comparison of these patterns between countries have not been made. To attempt this, bat activity at both rotor and ground height from 3 countries and 5 wind farms were chosen for analysis: Portugal (2), Poland (1) and South Africa (2).

For each project, bat activity data was collected by a pair of automatic acoustic bat detectors, installed at static locations at rotor level and ground level. Depending on the project, the detectors located at rotor level were installed at minimum height of 21 meters and maximum height of 80 meters, and detectors located at ground level were located between 7 and 10 meters. Each location was characterized in terms of habitat type present in a 500 meter radius; bat species grouped by flight height, roosting type and hunting behaviour; and general weather conditions. In all projects, monitoring covered all the periods of expected bat activity in a year, so that all phenological bat phases are represented.

Projects were selected to represent scenarios of pre-construction and operation phase and data was compared between these two scenarios in terms of bat patterns over the night and year (such as seasonal patterns) and activity versus environmental variables (wind speed, air temperature and moon light). Only overall bat activity or activity of bat group types (e.g. aerial hawkers) was analysed since one of the goals was to determine if bat activity followed a similar pattern between different countries, regardless of species, habitat and weather. Another goal was to determine if the difference in pattern between ground level and rotor level is similar between countries.

Bat activity patterns, over the night and year, and its relation with environmental variables are expected to be similar for the overall community and between main bat group types, and our preliminary results support just that. The results of this study will allow making generalisations on bat activity and discuss its use for conservations purposes, such as, to provide information to support general cross-country guidelines regarding wind farm impact studies and mitigation strategies.

Practical techniques for restoring blanket bog on previously afforested land to mitigate habitat impacts from windfarm development in upland Scotland

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Abstract

Areas of high wind yield in Scotland are often co-located with peatland habitats, several of which are categorised as priority habitats under the EU Habitats Directive due to their high biodiversity value and soil carbon storage potential. Recognising the sensitivities of developing on peatland habitats, ScottishPower Renewables has committed to restoring over 2500ha of former commercial forestry to natural peatland habitats, as part of mitigation and enhancement schemes for 10 projects in upland Scotland. Since existing techniques to achieve this were poorly understood, this study sought to develop successful, efficient, cost effective methods for restoring deforested blanket bog habitat over large areas without causing adverse environmental impacts.

Monitoring showed the conventional techniques of ditch blocking and grazing management were unsuccessful in restoring the hydrology of peatland habitats due to the ridge and furrow pattern left behind post felling. A trial was undertaken to identify a technique to disrupt the ridge/furrow pattern, eliminate regenerating trees and restore functional hydrology. A suitable method ("ground-smoothing") was developed, whereby a low ground pressure excavator flipped stumps into furrows and tracked over the area leaving a flattened surface. A less intensive treatment ("cross-tracking") was identified for areas with smaller stumps which used the excavators' weight to push the stumps into the peat mass and flatten the area.

A formal landscape scale study was designed at two sites to investigate the effectiveness of the techniques and assess potential impacts. The first site was treated in 2013 and contained four experimental blocks, each with a ground-smoothed and control plot. The second site was treated in 2014 and consisted of three experimental blocks, each with a ground-smoothed, cross-tracked and control plot. Water table depth and regenerating conifer survival rate were measured to assess condition of the restored habitat, while vegetation response was monitored to indicate habitat quality.

Results showed the bog hydrology in all areas fluctuated seasonally, but variation in treated blocks was less than in control blocks. Both methods compacted the residual forestry material, reducing the distance between vegetation and water table to approximately half that of the control block (7-10cm) resulting in wetter surface conditions. This closer contact between plants and the bog water table promotes the growth of bog specialists such as Sphagnum mosses. Conifer regeneration, which was prevalent prior to treatment, was shown to be greatly reduced by both techniques.

Multivariate principal coordinate analysis was used to explore the early vegetation response and presented differences between treatment and control blocks. Ground-smoothed blocks were positively correlated with abundance of bog plants while control blocks were positively correlated with undesirable non-bog species. Cross-tracked blocks displayed an intermediate response. After several years the responses have become more distinct with the abundance of species of bog plants in treated areas significantly higher than the untreated areas ($p < 0.05$).

Ground-smoothing and cross-tacking are effective techniques for restoring deforested blanket bog habitat and have been shown to enable wind farm projects to deliver mitigation and compensation for impacts at a landscape scale.

Noise mitigation systems: Successes and lessons learnt during construction of wikinger offshore wind farm 2016

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Abstract

Iberdrola successfully installed 286 foundation piles in 2016 for the jacket foundations of the Wikinger Offshore Wind Farm in the German Baltic Sea. During the piling works sophisticated noise mitigation systems were used to reduce the impact on harbour porpoise and to comply with the noise limit of 160dB SEL re 1 μPa in 750m set by BSH as the licensing authority for offshore wind farms in the German Exclusive Economic Zone.

A noise prognosis prepared in the planning phase indicated that a noise reduction of at least 13 dB would be required to meet the required noise limit. In order to mitigate the impacts of offshore pile driving on harbour porpoise and to reduce underwater noise propagation to comply with the required noise threshold, Iberdrola commissioned the design of a custom made Small Bubble Curtain (SBC) attached to the piling template in addition to separate Double Big Bubble Curtain (DBBC). A Hydro Sound Damper system for jackets (HSD-j) was also made available as contingency in case the bubble curtain systems alone were not able to reduce the piling noise sufficiently. Huge efforts were taken to optimise the piling design and to apply best available noise mitigation systems specific to the site conditions of the Wikinger project. This included a pre-construction pile testing campaign which provided information on pile driving performance at several locations and noise propagation levels. The combined effectiveness of all measures resulted in piling noise levels complying with the threshold of 160dB SEL re 1 μPa in 750m.

Although the experiences and effectiveness of noise mitigation systems has improved since early development, results have shown that noise reductions cannot be easily transferred between projects and noise mitigation systems need to be specifically suited to the project design and site conditions. For the Wikinger project huge technical and logistical efforts were undertaken along with significant investments in order to optimise noise mitigation, minimise the impacts on harbour porpoise and to comply with the piling noise threshold. Overall the

noise mitigation implemented resulted in noise levels well below the limit of 160dB SEL re 1 μPa in 750m and assured a continuous installation process of the foundation piles.

Adding value to wind farm projects by integrating ecosystem services in the environmental impact assessment process

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Abstract

Integrating Ecosystem Services (ES) approach into Environmental Impact Assessment (EIA) process has been tested in recent years following a path of making the invisible visible. This means looking for not only impacts but also dependencies of industries and businesses and, in case of the EIA, specific projects. Several approaches and methodologies have been applied when performing this integration and not always the benefits of it are clear. When it comes to wind farm (WF) projects, the examples are fewer which makes it more difficult to understand the challenges and benefits of these exercises. Not having a clear idea of these benefits undermines the confidence and will of developers and project owners to pursue this approach.

This presentation assesses examples available online of EIA where ES approach was applied and how each approach add value to the decision-making process. It identifies 1. which ecosystem services are considered; 2. how data is collected and analysed; 3. which impacts and dependencies are critical to the assessment; and 4. how conclusions influence the environmental licensing and management plans.

Based of the analysis, we determine which factors bring benefits to the process and we propose a framework that can help the integration of ES in the EIA of WF projects with focus on adding value to the environmental assessment.

Call for action: Adaptive management in practice

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Abstract

The concept of adaptive management is relatively new in the management of biodiversity applied to wind energy projects. Nevertheless, in the present there are several studies based on the use of adaptive management and the concept is widely considered to be one of the best available solutions in the presence of uncertainty for managing ecosystems.

In Portugal a formal approach to adaptive management is not yet included in environmental process. Despite some instruments consider a linkage between impacts, mitigation and monitoring, the path to follow this kind of approach is not clear.

A step-by-step approach was constructed and can be applied to wind farm projects. This approach encompasses two major phases: set-up phase and iterative phase. The decisions made during the set-up phase are sustained by baseline information and pre-construction monitoring results and oriented by the mitigation hierarchy. The iterative phase is a sequential process of action and decision-making where actions are adjusted to monitoring results.

We will demonstrate the application of this using a national case study. This case study has over 10 years of results (2005-2016) and is an outcome of an active decision-making strategy, consequence of the collaboration and engagement of several stakeholders (e.g ecological specialists, developers, regulators/authorities).

Crucial assumptions to the success of an adaptive management program for a given wind farm are the engagement of different stakeholders and the capability to be a dynamic process, allowing to be adjusted in result of monitoring.

Bat activity at nacelle level and its implications for mitigation

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Abstract

There has been a rapid expansion of wind farm construction in recent years. It has become increasingly clear that wind farms can pose a severe threat to certain bat species and that mitigation schemes are necessary. It is therefore urgent to find a solution that is beneficiary and acceptable from both a bat conservation and a developer perspective.

In order to address this problem microphones were mounted at nacelle level on twelve wind turbines, at seven different wind farms in southern Sweden, to continuously monitor bat activity. The surveys were conducted from the end of June until the end of October, with individual wind farms monitored between one and three seasons. All bat recordings were time stamped and for the analysis we had access to wind speed and temperature data with 10 min resolution. The analysis was carried out in MatLab.

At this time our results are preliminary, but final results will be presented at the conference. However, we know that bat activity differed by a hundredfold between wind farms, mainly reflecting variations in bat species diversity and abundance, but showed the same patterns with respect to timing and weather factors at all sites. Activity at rotor height was dominated by *Nyctalus noctula* but also included *Vespertilio murinus*, *Eptesicus nilssonii* and *Pipistrellus spp*. Most recordings at rotor height also occurred between mid August and early September, during nights characterized by low wind speed and high temperature. Overall, the 90 percentiles for wind speed and temperature were < 6 m/s and $> 14^{\circ}$C, respectively. Our results are in agreement with data from other studies and countries, which suggests that our results have wide applications. The strong temperature dependence is an important novel finding, suggesting that it may be unnecessary to stop the rotors unless temperature exceeds 14°C.

Based on our results we believe that a more fine-tuned curtailment can substantially cut mortality rates for bats at a low cost for wind companies. Furthermore, we believe that curtailment based our results are widely applicable in temperate zones.

Assessing avian avoidance rates and collision risk at offshore wind farms from aerial digital images

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Abstract

The avoidance rate is the key input variable in collision risk models (CRM) requiring a three-dimensional empirical analysis of the spatiotemporal distribution of birds relative to individual wind turbines. However, the number of potential seabird collisions resulting from CRM has frequently been based on precautionary, possibly unrealistically low, avoidance rate estimates. Collision rates are therefore likely to be overestimated in current environmental impact studies. These inflated mortality estimates are often accepted by decision makers, making wind farm consent more difficult. This approach calculates macro- and micro-avoidance through the statistical analysis of the spatial distribution of birds in flight relative to the turbine positions. Here, we present a novel approach for estimating seabird macro- and micro-avoidance of offshore windfarms from high-resolution digital images from aerial survey. The method makes it possible to gather information on bird distribution and individual approach distances to offshore wind turbines over a wide spatial scale and in three dimensions. We present results from a case study based on four post-construction aerial surveys of the Greater Gabbard offshore windfarm (GGOWF) carried out in 2014 during a period of high Northern Gannet (Sula bassana) autumn passage off the East Anglian coast in the southern North Sea. Due to the widespread use of potentially precautionary avoidance rates the Gannet has become a major consenting risk for offshore windfarms in the North Sea and elsewhere. In total 336 gannets were recorded during the four surveys of which eight individuals were recorded within and 328 individuals outside the wind farm footprint. A zero-inflated negative binomial model was used to describe the relationship between the distance to the nearest turbine and Gannet counts outside of the wind farm footprint. Gannet numbers increased significantly from zero close to the turbines to background density levels 2 km away from the nearest turbine. A macro-avoidance value of 95.02% was calculated for gannets as the percentage change from their background at sea density outside of the wind farm area compared to their density within the wind farm footprint. Observing no birds closer than 359 m to a turbine suggested 100%

micro-avoidance and an overall avoidance value of 100%. In conclusion, it is not unreasonable to suggest that an avoidance rate of 99.5%, at least for gannets on autumn passage, may be appropriately precautionary for use in CRM. Our digital aerial survey approach can capture the avoidance behaviour of seabirds efficiently and rapidly over a wide spatial scale. Results arising from the use of this method will contribute to reducing uncertainty in predicting impacts from offshore wind farms on seabird populations at both a local and national level.

Case examples of barrier effects of wind farms on birds in Japan

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Abstract

Paths that birds follow during migration and for daily movements change because of the existence of wind farms (Rydell et al. 2012), which require the birds to use more energy to fly, leading to lower breeding success and survival rate. These barrier effects have become a matter of concern (Masden et al. 2010), beginning with the cases of offshore wind farms in countries such as Denmark (Desholm & Kahlert 2005, Pettersen 2005). In Japan, barrier effects are a rarely discussed issue in environmental impact assessments because only a few offshore wind farms exist in the country and most of the attention regarding these farms goes to bird mortality caused by collision with wind turbines.

In Europe, changes in the paths that birds follow during migration and for daily movement are considered an impact caused by the construction of wind farms (Gove & Langston 2013). Based on the results of studies on barrier effects, construction of wind farms is avoided along migration routes and paths for daily movement of birds susceptible to wind farm impact (Planungsgemeinschaft Rheinhessen-Nahe, Teilplan Windenergienutzung 2012). Whereas such an approach is considered necessary in Japan as well, currently, even the types of birds on which barrier effects occur are unknown.

Thus, we conducted radar surveys to find out which bird species are subject to barrier effects. Surveys at sites located near wind farms were conducted during the autumn migration period of 2014 at Sada-misaki Peninsula, Ehime Prefecture, and Cape Soya, Hokkaido; during the wintering period of 2016 at Lake Kitagata in Awara-City, Fukui Prefecture; and during the autumn migration period of 2016 at Nikaho Highlands, Akita Prefecture.

The results of the radar survey conducted from September 22 to 28, 2014 at Sada-misaki Peninsula confirmed that Oriental honey buzzards, Grey-faced buzzard, and Eastern buzzards avoided wind turbines as they flew.

The results obtained during the period from November 17 to 22, 2014 at Cape Soya confirmed that Steller's sea eagles passed over the turbines without avoiding them and hence no barrier effects occurred when they were flying above the turbines. However, effects did

occur when they flew at or below the height of the turbines, in which case they started avoiding the turbines from a distance of about 300 m. Barrier effects occurred on white-tailed eagles regardless of the height of the flight.

The radar survey conducted at Lake Kitagata from February 19 to 25, 2016 showed that white-fronted geese that flew toward the turbines avoided them, indicating the occurrence of barrier effects.

The radar survey conducted at Nikaho Highlands from October 25 to 28, 2016 showed that swans avoided wind turbines on the ridge as they flew, indicating the occurrence of barrier effects.

The survey results confirmed that barrier effects due to construction of wind farms occur in Japan, too, for wild geese, swans, and raptors, as has been reported by Hötker et al. (2006). To reduce the occurrence of barrier effects in Japan in the future, policies are needed to avoid construction of wind turbines along the paths that these bird species follow during migration and for daily movements.

Species and wind farm sensitivity index for seabirds and landbirds in Hokkaido

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Abstract

When selecting sites for wind farms, operators in the Germany and UK etc. sometimes use spatial plans and sensitivity maps that consider birds' sensitivity to onshore and offshore wind farms (Garth & Hüppop 2004, Bradbury etc. 2014, The Crown Estate 2015).

Because Japan is home to many types of bird species and has a large population of birds, and the construction of many large-scale wind farms are being planned both onshore and offshore, it should learn from the actions taken by other countries for future farms, whereby the sites are selected in consideration of birds' sensitivity to wind farms. Japan should ensure that siting of wind farms is in harmony with conserving birds' habitats and aim at introducing truly environmentally sound energy.

Thus, we developed a species and wind farm sensitivity index for land birds and seabirds, which serves as the basis for spatial planning and sensitivity mapping. The index was developed based on the results of two bird censuses: one conducted at sea off Nemuro and Haboro in Hokkaido and the other conducted on land in most northern part of Hokkaido. Based on the index, we identified the bird species potentially vulnerable to the construction of wind farms in Hokkaido.

In developing the sensitivity index, we used BirdWatch Ireland (2015) as a reference for land birds, taking into consideration the presence or absence of mortality due to collision both in Japan and in other countries, and Garthe & Hüppop (2004) as a reference for seabirds.

The results showed high Species Sensitivity Scores (SSSs) for land birds including white-tailed eagles *Haliaeetus albicilla*, Steller's sea eagles *Haliaeetus pelagicus*, Mountain hawk-eagles *Spizaetus nipalensis*, Japanese cranes *Grus japonensis*, Northern goshawks *Accipiter gentilis*, Bean geese *Anser fabalis*, White-fronted geese *Anser albifrons*, Peregrine falcons *Falco peregrinus*, Eastern marsh harriers *Circus spilonotus*, and Latham's snipes *Gallinago hardwickii*. Land bird species that are endangered and also have high flight risk factors showed high SSSs. The seabirds that showed high Species Sensitivity Index (SSI) scores included Ancient murrelets *Synthliboramphus antiquus*, pelagic cormorants *Phalacrocorax pelagicus*,

Pomarine skuas *Stercorarius pomarinus*, Common murres *Uria aalge*, Harlequin ducks *Histrionicus histrionicus*, and Common scoters *Melanitta nigra*. In particular, endangered species or those with high habitat risk factors showed high SSI scores. The Wind Farm Sensitivity Index (WSI) prepared by applying the SSI developed here to the results of the seabird census surveys in Nemuro and Haboro indicated that sensitivity rose as proximity to shore increased and was high in many sea areas around feeding sites and nesting colonies.

In this study, it was found that wind farms should not be constructed in the following areas in Japan in the future, from the perspective of bird conservation: onshore farms near habitats of endangered species that are vulnerable to wind farms based on their flying behavior and offshore farms in coastal zones within several kilometers of the coast.

Individual passerine flight decisions at the German North Sea coast

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Abstract

The German coastlines are part of the East-Atlantic Flyway and are thus regularly crossed by small passerines on their way from the breeding to the wintering grounds and vice versa. Due to a long history of bird watching and ringing on the coast as well as on the islands, the general travelling routes and migration periods of many species are well known. However, individual flight paths are highly variable. Even within species, an individual bird may decide to follow the coast line or cross the ecological barrier of the open sea. Especially in small passerines, which do mostly travel at night and are too light to carry a GPS-transmitter, we know little about individual route decisions.

In our project, we use a chain of telemetry receiver stations covering the whole German North Sea coast in order to follow individual flight ways of small passerine birds for the first time in this region. A number of species including thrushes and warblers are caught during migration prior to reaching the coast line. Each bird is measured, sexed, aged, blood sampled and tagged with a very light (0.4 g) radiotelemetry-transmitter. Individual flight paths are then automatically followed by our system. Data collection is ongoing until the migration period is over. Preliminary data from the first season will be presented. Research questions we want to address include: Which intrinsic (e.g. age, body condition) and extrinsic (e.g. weather) factors influence individual flight decisions' Which structures, e.g. islands or wind parks do attract birds or are actively avoided? Given the rapid extension of offshore wind parks in the German North Sea, broadening the knowledge on individual flight behaviour over sea can help to better assess a potential impact on migratory bird populations.

Additionally, a better understanding of birds' flight decisions may thus help to carry out the construction and operation of offshore wind parks in an ecologically most compatible way.

Habitat displacement of small land birds at wind farms in Japan

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Abstract

Construction of wind turbines affects birds in three ways, collision to wind turbine, displacement from natural habitat, and habitat loss. Collision to wind turbines has drawn great attention and been studied well, while displacement from natural habitat is poorly understood, especially for small land birds. To clarify the effect of wind farm on presence of bird species, census surveys were conducted near and far wind turbines at ten wind farms in Japan. I will discuss the species difference of response to wind turbines as well as difference between breeding and wintering season, or so on.

Predicting regional distribution of white tailed eagle in winter to inform wind farm placement in Hokkaido, Northern Japan

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Abstract

As wind power generation facilities has been extensively installed, there is growing concern for their environmental impacts. Bird collision is one of the most serious problem of them, especially for threatened species such as large raptors. In Japan, the number of wind farms has been rapidly increasing over the major wintering area for eastern population of white-tailed eagle. This may lead to an increase in their mortality. Actually, at least 43 individuals of this species collided with wind turbines for these 12 years. Because most collisions occurred during winter, detailed description of their wintering distribution would be helpful to prevent inappropriate location of wind farm construction. In this study, we predicted regional distribution of white-tailed eagle in winter from the broad scale monitoring data. Then, we superimpose a wind speed map on the predicted distribution map, as well as comparing the predicted occurrence probability between the locations where eagles previously collided with wind turbines and those where no collision has arose in the past. In our results, altitude, forest area, snow depth and proximity to the coast and river were used to predict eagle's distribution in our study area. Their distribution largely overlapped with potential areas for wind power generation facilities, suggesting a potential conflict between wind energy industry and conservation of this species. In addition, occurrence probability of this species is significantly higher at the location of wind farms where bird collisions previously arose. These results suggest that wind farm placement should be carefully selected by considering the eagle wintering distribution to avoid the risk of bird collisions.

Effects of the Lista wind power plant on roadside revegetation and the space use of moose, red deer and roe deer

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Abstract

Being relatively tall, wide-spread landscape elements, wind power plants (WP) with turbines, access roads, buildings and power lines affect local ecosystems, potentially disturbing vegetation communities and wildlife. With data spanning before (2011), during (2012) and after (2013-2015) construction of the Lista WP (31 turbines of 2.3 MW), we studied vegetation succession along newly constructed roadsides and the local space use and population trends for three cervid species; moose (*Alces alces*), red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*). Plant species composition was registered and compared for plots in disturbed/revegetated versus undisturbed areas within the WP area. Cervid space use was tested by sampling and comparing fecal pellet-group distribution along the same pre-defined transects for all years. We found that roadside plant diversity in revegetated areas matched undisturbed diversity 3 years after construction. However, none-native plant species introduced during revegetation also migrated into undisturbed areas after construction, and remained after three years. The introduction/use of none native species during revegetation is not recommended in restoration after construction, and led to temporary lower plant diversity and potentially long-term colonization of surrounding plant communities. At the local scale, space use by red deer and roe deer showed avoidance towards roads under construction of the WP, and subsequent habituation 3 years after construction. There was too little data to test this for moose. Increased pedestrian activity (walking, jogging, dog walking, bicycling) and hunting may be important factors for the decline in local use of roadsides in the WP area by cervids the first years. Regionally, we are in the preliminary stage of investigating a potential decrease the first 2 years after construction for all three cervid populations in the WP area compared to the rest of the region, with increasing trends the last year, three years

after construction. Additional data is required. Continuing and combining these data-series in future studies can provide a unique opportunity to assess ecological impacts of the Lista WP.

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