NINA Report 693

Conference on Wind energy and Wildlife impacts

Proceedings

Conference on Wind energy and Wildlife impacts, 2-5 May 2011, Trondheim, Norway

Roel May, Kjetil Bevanger (eds.)

CEDREN Centre for Environmental Design of Renewable Energy

NINA Norwegian Institute for Nature Research




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Norwegian Institute for Nature Research

Proceedings

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Roel May, Kjetil Bevanger (eds.)

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Foreword

Over the last 4-5 years NINA/CEDREN has been running the BirdWind-project, focusing mainly on bird impacts at the Smøla wind-power plant. As 2010 was the final year of extensive field activities, 2011 is the year for dissemination of findings. Consequently this was the perfect time for us to invite colleagues from the rest of the world to share knowledge on issues on wind-power generation and wildlife impacts, and exchange information across countries and continents. We are overwhelmed by the interest we have received, with nearly 300 delegates from more than 30 countries. Thank you for taking your time to come to Trondheim! Norway is an expensive country, and we have tried to keep the conference fee as low as possible. That has been possible due to our sponsors; The Research Council of Norway (NFR), Statkraft, The Norwegian Water Resources and Energy Directorate (NVE), The Directorate for Nature Management, The Norwegian Electricity Industry Association (Energy Norway) and Mester Grønn. There are several logistical challenges connected to such an arrangement, and we wish to acknowledge Elin Kolden, Siv Simonsen and Odd Petter Haugseth from Stjørdal Næringsforum for their untiring organisational efforts over a long period of time. Due to the great number of high-quality abstracts received, the Scientific Committee faced a great challenge during the selection procedure. At one time we actually considered going for parallel sessions. However, we finally decided to organise poster sessions, so that nobody has to choose between presentations which may both be of interest; and this has resulted in the submission of many high-quality posters! We would like to thank the Scientific Committee for its efforts: Roel May (NINA; Chairman), Dr. Rowena Langston (RSPB, UK), Prof. Dr. Johann Köppel (Technical University of Berlin, Germany), Dr. Mark Desholm (NERI, Denmark), Dr. Andrew Gill (Cranfield University, UK), Dr. Shawn Smallwood (USA) and Dr. Edward Arnett (Bat Conservation International Inc., USA). We also thank them for their voluntary support as chairmen of the different sessions. Not at least we will like to thank our keynote speakers Prof. Dr. Thomas Kunz (Boston University, USA) and Dr. Elisabeth Masden (Environmental Research Institute, UK). Bjørn Iuell (Statkraft, Norway), Dr. Manuela de Lucas (Doñana Biological Station, Spain), Dr. Edward B. Arnett, Prof. Johann Köppel and Simon Coote (Scottish Government, Scotland) are acknowledged for their participation on the panel discussion, as are all speakers for their presentations and contributions to the conference proceedings.

18.04.2011 Kjetil Bevanger

Welcome

Energy from renewable sources has become increasingly important as part of energy policies, partly due to climate change scenarios. With the present targets for renewable energy production in many countries, and the huge world potential for wind-power generation, wind-power development has become a very important issue from a political, economical and ecological point of view. Ecological impacts of wind-power generation are debated intensively within several fora, and there is a need for a firm knowledge-base on the impacts on wildlife, as well as innovative and efficient mitigation measures.

Norway has long been a net exporter of renewable energy from hydropower, and is in the forefront of wind energy development. 2010 is the last year of a major research programme on wildlife and wind-power generation in Norway (*BirdWind*). The programme focussed on research tools and methodological development, as well as population effects on wildlife (particularly the white-tailed eagle). Much work is in progress on these issues worldwide, and during the Conference on Wind energy and Wildlife impacts (CWW2011) we have gathered colleagues from all over the world to share experiences on how wind-power plants may affect wildlife, and discuss how we should meet the challenges created by the world-wide increased activity in large scale wind-power plant construction. The organizing committee welcomes all attendees to the conference and Trondheim, Norway!

Organiser information

The Norwegian Institute for Nature Research (NINA) is Norway's leading institution for applied ecological research. NINA is responsible for long-term strategic research and commissioned applied research to facilitate the implementation of international conventions, decision-support systems and management tools, as well as to enhance public awareness and promote conflict resolution. The institute employs a staff of approximately 190 and directs well-equipped laboratories and facilities at seven locations in Norway. NINA offers broad-based ecological expertise covering the genetic, population, species, ecosystem and landscape level, in terrestrial, freshwater, and coastal marine environments. In addition, NINA addresses a wide variety of interdisciplinary issues involving both ecologists and social scientists, and plays an important role in European and other international research activities.

Centre for Environmental Design of Renewable Energy (CEDREN) is one of the eight Norwegian Centres for Environment-friendly Energy Research (CEER) established in 2009 to obtain a substantial increase in the research and development in the fields of renewable energy in Norway. NINA is one of the main R&D partners in CEDREN, and the centre project BirdWind forms an essential scientific basis for the CWW 2011 conference.

Conference programme

Scientific programme

Over 150 abstracts for oral and poster presentations have been received by the scientific committee from 25 different countries. The scientific committee consisted of:

- Dr. Roel May (*Norwegian Institute for Nature Research, Norway*) [Chairman]
- Dr. Rowena Langston (*Royal Society for the Protection of Birds, United Kingdom*)
- Prof. Dr. Johann Köppel (*Technical University of Berlin, Germany*)
- Dr. Mark Desholm (*National Environmental Research Institute, Denmark*)
- Dr. Andrew Gill (*Cranfield University, United Kingdom*)
- Dr. Shawn Smallwood (*self-employed, United States*)
- Dr. Edward Arnett (*Bat Conservation International Inc., United States*)

The scientific committee has reviewed all abstracts and selected those oral presentations that would best represent the quality and breadth of research carried out throughout the world. All other abstracts have received the opportunity to present their work on a poster. Posters will be presented throughout the conference, and there will be specific poster breaks each afternoon from 15:00 to 16:00 local time each day. This allows everyone to take in the poster presentations, and set off time to interact more personally with those who are interested in your research.

The detailed scientific programme and list of participants are printed as separate appendices to these proceedings.

The conference starts with a general plenary session where we have the honour to present the following speakers:

- Opening speech: Norunn Myklebust (*Managing Director NINA*)
- Bjørn Iuell (*Statkraft AS, Norway*)
- Dr. Kjetil Bevanger (*Norwegian Institute for Nature Research, Norway*)
- Micheal O'Briain (*EU DG Environment*)
- Dr. Rowena Langston (*Royal Society for the Protection of Birds, United Kingdom*)
- Dr. Mark Desholm (*National Environmental Research Institute, Denmark*)

The following two days we have the honour to start the day with keynote oral presentations from our invited speakers:

- Prof. Dr. Thomas Kunz (*Boston University, United States*)
- Dr. Elisabeth Masden (*Environmental Research Institute, United Kingdom*)

The oral presentations of the scientific programme are structured in the following sessions:

- **EIAs and site selection** (*Convenor: Prof. Dr. Johann Köppel*)
  This session aims to present the current knowledge on site selection and turbine placement, and site-specific effects in expected vulnerability for wildlife. Also, this session focuses on how EIA should be performed (best practise), and which aspects are crucial in these (e.g. Maritime Spatial Planning).
- **Pre- and post-construction monitoring** (*Convenor: Prof. Dr. Johann Köppel*)
  This session aims to present the current knowledge gained from pre-and post-construction studies on site-specific effects in expected vulnerability for wildlife.
- **Fatality studies** (*Convenor: Dr. Edward Arnett*)
  This session focuses on issues related to estimating fatalities from wind turbines.

- **Species-specific vulnerability and population effects** (*Convenor: Dr. Rowena Langston*)
  This session aims to present how different species may differ in their vulnerability due to their population status, behaviour or other (e.g. aerodynamics). Also, the effects (both positive and negative) of wind energy on wildlife populations are presented.
- **Behavioural and spatial responses of wildlife** (*Convenor: Dr. Edward Arnett*)
  This session aims to present how wildlife may be affected by wind energy (be that single turbines or entire wind-power plants) in their behaviour, and which spatial responses (e.g. displacement, avoidance) result from these.
- **Collision risk modelling** (*Convenor: Dr. Shawn Smallwood*)
  This session aims to present the best available knowledge and new approaches to model collision risks.
- **Methods and statistics** (*Convenor: Dr. Mark Desholm*)
  This session focuses on statistical issues and methods developed to render improved insight in wildlife impacts of wind energy.
- **Tools and technology** (*Convenor: Dr. Mark Desholm*)
  This session aims to present which current and future tools and technology may be used to study effects of wind energy production on wildlife.
- **Cumulative effects** (*Convenor: Dr. Roel May*)
  This session addresses possible cumulative effects several wind-power plants may have on wildlife.
- **Mitigation and compensation** (*Convenor: Dr. Andrew Gill*)
  This session aims to present possible mitigation measures which may be employed to reduce detrimental effects, and how compensation schemes may be tailored to balance the negative impacts.
- **Future challenges: offshore and onshore** (*Convenor: Dr. Roel May*)
  As closure for the conference on wind energy and wildlife impacts, this last session will focus on the research and management-related challenges lying ahead of us. Especially offshore wind energy development will be a central theme in this; with its possible impacts on wildlife, and new conflicts of interest concerning area use. This session will be concluded with a panel debate to discuss relevant issues.

Concluding debate

The conference will conclude with a panel debate focusing on the challenges – onshore and offshore – ahead of us. The debate aims to set focus on the envisioned paramount topics within the framework of the main conference theme. To ensure that the poster and oral presentations of the conference will provide the red thread to the discussions, the convenors of the different oral sessions will at the end of each day sort out the most appropriate topics for the panel debate. After a short presentation of these topics, each panel member will be introduced and each will be given five minutes to make an opening statement from their respective viewpoints given their affiliation and expertise. In the following discussions, the audience is allowed to hand in written questions for the panel to elaborate on the selected topics. Thus, the panel debate may summarize the conference essence, and provide valuable input to direct future research on wind energy and wildlife impacts.

The panel consists of:

- Edward Arnett (*Bat Conservation International Inc., USA*)
- Bjørn Iuell (*Statkraft AS, Norway*)
- Johann Köppel (*Technical University of Berlin, Germany*)
- Manuela de Lucas (*Doñana Biological Station, Spanish National Research Council, Spain*)
- Simon Coote (*Energy Consents & Deployment, Scottish Government, Scotland*)

Evening workshops

Workshop on Estimating Fatality at Wind-Power Plants

Tuesday 3rd of May 2011 19.30 – 21:30

Chairs: *Manuela Huso (Dept. of Forest Ecosystems and Society, Oregon State University) & Regina Bispo (Dept. of Statistics, ISPA University Institute)*

The workshop aims to bring together researchers to exchange experiences and knowledge on estimating fatality issues. The workshop aims to 1) improve participants' understanding of the issues involved in accurately and precisely estimating fatality (e.g. assumptions regarding carcass input rates, searcher efficiency, sample size in bias trials); 2) introduce them to software tools with which to estimate fatality; 3) generate ideas for further needs in estimation software. First, a general conceptual model will be presented of why what we observe is not reflective of what was killed and why observed fatality cannot serve as a simple index of actual fatality. Thereafter possible biases and their correction factors – searcher efficiency, plot limitations (unsearchable areas, finite areas relative to entire site, etc.), search interval, and carcass persistence – are discussed. Statistical issues related to estimating measures of precision of fatality estimates will be addressed. Also constraints on estimation (when our numbers can be considered reliable/accurate, when not) are discussed. After this more conceptual introduction, a practical session regarding a software application will be presented. Topics related to data format requirements, implementation, and interpretation of output will be highlighted. The workshop finalize with an open discussion on future directions.

Workshop on Large terrestrial mammals and wind power – is there a problem?

Wednesday 4th of May 2011 19.30 – 21:00

Chairs: *Jan-Olof Helldin (Swedish University of Agricultural Sciences, Swedish Biodiversity Centre) & Francisco Álvares (CIBIO-UP, Research Center in Biodiversity and Genetic Resources, Porto University, Portugal)*

Studies addressing the effects of wind power on wild terrestrial mammals such as deer and carnivores are few. Any impacts that can be documented on these taxa may have effects on conservation and wildlife management, and should therefore be considered in environmental assessment. At present, handling officers have little support how to deal with the issue in the wind power planning process. This workshop aims at synthesizing the best available knowledge in the field, based on experiences and views of the participants, and identifying how this matter should be addressed, if at all. Based on a brief overview of some empirical studies, participants will discuss around a few central questions, related to the main question in the workshop title. Discussions will be summarized in a short report.

Proceedings – oral presentations

The abstracts are given in alphabetical order on the presenting author.

ASSESSING ECOLOGICAL RESPONSES OF WOLVES TO WIND POWER PLANTS IN PORTUGAL: METHODOLOGICAL CONSTRAINS AND CONSERVATION IMPLICATIONS

Francisco Álvaras[1], Helena Rio-Maior[2], Sara Roque[3], Mónia Nakamura[2], Duarte Cadete[3], Sara Pinto[3], Francisco Petrucci-Fonseca[3]

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[2] VERANDA, Portugal
[3] GRUPO LOBO, Departamento de Biologia Animal da Faculdade de Ciências da Universidade de Lisboa, Portugal.

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Abstract

Wind-power development has substantially increased in the last decade in Portugal and associated structures mostly overlap with wolf range, which raises major conservation concerns as a potential source of disturbance to this endangered carnivore. However, a comprehensive evaluation is greatly hampered by difficulties in studying wolf ecology and current lack of knowledge on the impacts of wind energy development on non-flying animals, especially large mammals. A research program was initiated in 2006, to: i) establish a methodological protocol for assessing impacts and monitoring wolf ecological responses to wind farms; ii) evaluate potential effects of wind farms on wolf space use and reproduction; iii) apply efficient mitigation and compensation measures. Field methods are based on howling and sign surveys, scat quantification through abundance indices and GPS telemetry.
Preliminary results demonstrate that: i) road network built for wind-power development lead to a considerable increase in traffic, especially during construction of wind farms; ii) wolves continue to use areas with wind farms; iii) wolf presence tends to decrease with the cumulative number of turbines; iv) spatial responses of wolves to wind farms appear to depend on the number and proximity of turbines to important pack homesites and prey availability; v) wolves abandon or do not regularly use breeding sites located in the proximity of wind turbines; vi) wolves select breeding places at a lower altitude after wind farm construction, as a response to related disturbance in mountain ridges. Wind farms induce important changes in wolf space use, selection of and fidelity to reproduction sites and reproductive success. These behavioural and spatial responses may constrain connectivity within and between pack territories and increase reproductive instability, especially in already highly humanized landscapes as Portugal. Based on these findings, several preventive mitigation measures have been applied during EIA and pre- and post-construction of wind farms.

WHICH RADAR SYSTEMS ARE SUITABLE TO STUDY WHAT KIND OF QUESTION? – AN OVERVIEW

Janine Aschwanden, Valère Martin, Erich Bächler, Thomas Steuri, Felix Liechti

Swiss Ornithological Institute, Switzerland

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Abstract

High constructions like wind farms are potentially dangerous obstacles with which birds might collide. Such a risk mainly exists during night or when the visibility is reduced due to bad weather conditions. In order to assess impacts of on and off-shore wind farms on birds, data about the temporal and spatial pattern of bird migration are needed. Radar observations are an adequate way to register diurnal and nocturnal movements of birds. However, not every type of radar system and measuring method is suitable to investigate any kind of question. Depending on the information needed, the correct type of radar has to be selected. For instance, for the investigation of individual behaviour another type of radar is required than for the quantification of bird migration in space and time.
The Swiss Ornithological Institute can not only look retrospectively back on several decades of experience in radar investigations, but is still improving and developing its systems. Different types of radar systems (tracking radars, fixbeam radars, marine surveillance radar) and measuring methods are presented. Furthermore, it is demonstrated by means of practical examples concerning environmental impact assessments, which radar systems are suitable to study what kind of question.

USING ACOUSTIC MONITORING TO MEASURE AND MITIGATE THE RISK OF BAT-COLLISIONS AT WIND TURBINES IN CENTRAL EUROPE

Oliver Behr[1], Robert Brinkman[2,3], Fränzi Korner-Nievergelt[4], Ivo Niermann[3]

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Abstract

We developed a "bat-friendly" operational algorithm for wind turbines that trades off the reduction in collision risk against the loss in revenue resulting from mitigation. The algorithm was based on acoustic bat activity data from continuous sampling at the nacelle of 70 randomly selected wind turbines in 35 facilities in five different habitat types in Germany from May to October 2008. Additionally, the area under 30 of these turbines was searched for animal fatalities each day between July and September.
First, we used a mixture model to relate acoustic bat activity to the number of fatalities found and to estimate the actual collision risk. Next, acoustic bat activity was modelled from the month, time of night, wind speed, temperature, and precipitation. Finally, using both models the collision risk was estimated from weather and temporal measurements alone and integrated in “bat-friendly” operational algorithms.
The number of bat fatalities found was highly correlated with the acoustic activity measured during the previous night. An estimated mean number of 6.0 bats per turbine had been killed during a period of 92 days from July to September. In most circumstances, to quantify the collision risk of bats at wind turbines from acoustic sampling will probably allow for a lower cost and higher precision of fatality numbers than conventional methods.
During times of high collision risk, rotors may be stopped to avoid fatalities. For different mitigation scenarios (varying in the number of bats being killed and the parameters used to predict activity), we calculated the resulting loss in energy production and the reduction in bat mortality. For our data-set, the median loss of energy was significantly lower than 1 % of the yearly revenue for a threshold of two bats killed per year during 138 days from mid June to end of October.

A WEB BASED APPLICATION TO ESTIMATE WILDLIFE FATALITY: FROM THE BIAS CORRECTION FACTORS TO THE CORRECTED FATALITY ESTIMATES

Regina Bispo[1], Manuela Huso[3], Gustavo Palminha[4], Nicholas Som[3,5], Lew Ladd[3], Joana Bernardino[4], Tiago A. Marques[6,2], Dinis Pestana[7,2]

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Abstract

In monitoring studies at wind farms, the estimation of bird and bat mortality caused by collision has crucial importance. The estimates of annual fatalities provide information about direct impacts by particular projects, allow comparisons between research studies, enable impact trend studies, provide a basis for legislation and enable the comparison with the impacts caused by other human activities. In order to estimate the mortality rate correctly, the observed number of carcasses must be adjusted both for scavenging removal and for search efficiency. To diminish estimation bias, recent studies advise new statistical procedures regarding the scavenging correction factor (Bispo *et al.*, 2010) and the estimator of fatality (Huso 2010). In this context, the complexity associated with the procedure may hinder its use. Consequently to help final users in applying the proposed methodologies we present an application that provides a friendly interface for the implementation of the statistical procedure in the R Environment for Statistical Computing that ultimately leads to the estimation of fatality. The user must provide the carcass persistence trial data, the searcher efficiency trial data and the gathered carcass data. From those, the application estimates the scavenging removal correction factor based on the best fitted parametric survival model (Bispo et al 2010), and the final output provides fatality estimates using the estimator proposed by Huso (2010). During the conference a laptop will be available to promote participants' hands-on contact with the software.

DEVELOPING WIND ENERGY IN IRELAND – CONSEQUENCES FOR OUR BIODIVERSITY AND ECOSYSTEM SERVICES

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Abstract

In response to climate change, the EU has set a target to achieve 20% of energy from renewable sources by 2020 (Directive 2009/28/EC). Consequently, Ireland has set targets of 40, 10 and 12% of energy coming from renewable sources for electricity, transport and heat, respectively, by 2020. Wind energy is expected to contribute significantly to achieving these targets given Ireland's large onshore and offshore wind potential. However, the potential impacts of these wind farm developments on Ireland's biodiversity remain largely unquantified. The SIMBIOSYS (www.SIMBIOSYS.ie) project was set up to investigate the impacts of a range of sectors on biodiversity and ecosystem services, with part of the project's focus on those measures that may help mitigate the effects of climate change. In this paper we aim to assess the potential positive and negative impacts of wind farms on Ireland's marine and terrestrial biodiversity, highlighting potential conflicts concerning the spatial distribution of our wind and biodiversity resources.

To help make these assessments an extensive review of the national and international scientific literature is used to highlight the potential positive and negative impacts of wind farm developments on biodiversity to date. Using GIS, spatial analyses are then used to quantify the extent to which wind resources and current and future wind farm developments overlap with biodiversity, using indicators such as Natura 2000 sites and Red Data List Plants. The outputs of these analyses are combined to help make recommendations on the sustainable future planning and management of wind farms in Ireland. Appropriate impact assessment and careful spatial planning will help ensure the direct benefits of green house gas emission reduction are maximised without compromising the protection of biodiversity in Ireland.

DISPLACEMENT EFFECTS OF PILE DRIVING DURING OFFSHORE WINDFARM CONSTRUCTION ON HARBOUR PORPOISES (*PHOCOENA PHOCOENA*)

Miriam Brandt[1], Ansgar Diederichs[1], Laura Wollheim[1], Klaus Betke[2], Georg Nehls[1]

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Abstract

Noise emissions from pile driving during offshore wind farm construction may injure marine mammals in the vicinity and cause large-scale disturbance and habitat displacement. So far little is known about the responses of marine mammals to such noise emissions making it difficult to predict possible impacts on their population and conservation status.
We investigated spatial and temporal responses of harbour porpoises to pile driving during construction of 92 mono-pile foundations in the Danish North Sea in 2008 and of 6 tripod and 6 jacket foundations in the German North Sea in 2009. We used passive acoustic monitoring devices that record harbour porpoise echolocation clicks (T-PODs), which were deployed at different distances from the construction site. Noise levels during pile driving were measured at various distances.
We found a clear impact of pile driving on the recordings of harbour porpoises, which stayed below average normal levels for up to 72 hours after pile driving in the near vicinity. A negative impact could be detected out to a distance of about 18 km, while at 22 km no negative effect was found. Here porpoise recordings temporarily increased. This shows that effects of wind farm construction reach over considerable distances and last much longer than previously assumed. We further found some differences between the effects of the different types of construction, possibly linked to the varying pile driving durations that were necessary. These results should be considered for future spatial and temporal planning of offshore wind farm constructions. Suitable mitigation measures should be adopted to reduce such far and long reaching effects on harbour porpoises and possibly other marine mammals.

EVALUATING THE STATISTICAL POWER OF DETECTING CHANGES IN THE ABUNDANCE OF SEABIRDS AT SEA

Niall Burton[1], Ilya Maclean[1], Mark Rehfisch[1], Henrik Skov[2], Chris Thaxter[1]

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Abstract

Offshore wind farms may potentially affect bird populations through the displacement of birds due to the disturbance associated with developments, the barrier they present for migrating birds and birds commuting between breeding and feeding areas, habitat change/loss and collision mortality. In current impact assessments it is often assumed that all birds that use the area of a proposed offshore wind farm would be displaced following construction, with some birds also displaced from a surrounding buffer zone. However, the extent to which current monitoring schemes are capable of detecting changes in abundance and options for improving survey protocols have received little attention. We investigated the likelihood of detecting changes in seabird numbers in UK offshore waters. Using aerial survey data, we simulated 50%, 25% and 10% declines and conducted power analyses to determine the probability that such changes could be detected. Additionally, increases in the duration and frequency of surveying were simulated and the influence of spatial-scale and variability in bird numbers were also investigated. Current monitoring schemes do not provide adequate means of detecting changes in numbers even when declines are in excess of 50% and assumptions regarding certainty are relaxed to less than 80%. Extending the duration and frequency of surveys would increase the probability of detecting changes, but not to a desirable level. The primary reason why there is a low probability of being able to detect consistent changes is because seabirds are inherently prone to fluctuations in numbers. Explaining some of the variability in bird numbers using environmental and hydro-dynamic covariates would increase the power of detecting changes.

THE EFFECT OF WIND FARMS ON VULTURES IN NORTHERN SPAIN – FATALITIES BEHAVIOUR AND CORRECTION MEASURES

Alvaro Camiña

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Abstract

Spain is one of the leading countries on wind energy, accounting for 20,155 MW installed by 2010. The study has been made in a large area, 300 km long and 50 km width, extending over eight provinces accounting for 170 wind farms and 4605 turbines. 89 wind farms were sampled between 2001 and 2009 for bird fatalities. Collisions involved 2191 griffon vultures *Gyps fulvus*, the most affected species with 75% of them being adult birds. Other species colliding were the cinereous vulture *Aegypius monachus* (2 individuals) and the Egyptian vulture *Neophron percnopterus* (4 individuals). Around 5-10% of turbines caused up to 60% of fatalities and mortality was temporally clumped and related with the species biology. It was lower in January- February while griffons are incubating, increasing in March when hatching. Then, it was reduced until September with a new increase at November-December. In order to explain causes in detail and reduce mortality a pilot study was carried out in a portion of this area (10 wind farms and 267 turbines) from 2005 to the present. Due to high mortality rates on griffons, 33 turbines were shut down by authorities in June 2008. Relationships between flight altitude at turbines area with both weather conditions and landscape features were analysed by means of statistical parametric GLM models. Results included air temperature; turbine features such as its slope and time of the year as significant variables. On the other side, the European policy against the Bovine Spongiform Encephalopathy (BSE) also contributed to increase both mortality and vulture's crossings through the turbines. Closure of vulture restaurants and carcass removal in the area caused food lacking for these birds. Then, they were forced to feed from a rubbish dump close to the turbines. Correction measures such as opening vulture restaurants since June 2009 and ceasing droppings at the rubbish dump significantly reduced flying rates of griffons to previous levels. In 2010 stopped turbines worked again. Since then vulture's mortality has been reduced by 80%. Finally, a marking programme with wing tags and GPS-satellite of six adult birds also contributed to a better knowledge of the griffon movements in the area. Monitoring of wind farms must be based on an adaptive management. Authorities and wind farm promoters must be aware of this. At least in Spain, the Environmental Impact Statement is the only document on which Bird and Fatalities Monitoring is based without considering the environment changes.

EX POST COMPENSATION FOR WHITE-TAILED EAGLE (*HALIAEETUS ALBICILLA*) IMPACTS AT THE SMØLA WIND FARM: AN APPLICATION OF EQUIVALENCY ANALYSIS

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Abstract

Current environmental compensation schemes for wind power fail to demonstrate a connection between the ecological damage and the ecological gains through restoration. Equivalency Analysis (EA) is a quantitative approach for scaling compensation that is frequently applied to the case of bird losses from oil spills. This EA uses a non-monetary "bird-year" metric to quantify the loss to the public associated with white-tailed eagle (WTE) turbine collisions at the Smøla Wind Farm (debit) and then -- using the same metric -- scales electrocution mitigation measures at nearby power lines as compensation (credit). The 36 WTE deaths from turbine collisions (2005-2010) result in a debit of approximately 1,320 discounted bird-years, which captures lost life expectancy from direct mortality and indirect reproduction losses. Preliminary data from 2010 indicate that WTE electrocution mortality on Smøla ranges from .01 to .15 deaths per year per pylon, depending on pylon type. We assume that a project that retrofits pylons to prevent WTE electrocution leads to a 100% reduction in such mortality, and then calculate the compensation credit per retrofitted pylon based on the life expectancy of a typical WTE that avoids electrocution. Given this information, we scale an appropriate amount of compensation (pylons retrofitted) under alternative scenarios, all of which ensure "equivalence" between loss and gain measured by our resource-based metric. Results indicate that scaled compensation varies depending on type of pylon and species addressed. This ex post study quantifies documented impacts through August 2010 and can be adjusted to reflect projected losses or revised in light of new information (e.g., displacement or reduced reproductive success). The study raises several issues for discussion: when compensation for wind power is appropriate, how much is enough, who is responsible, which species should benefit, what restoration projects are relevant, and what metrics best capture environmental loss and gain.

CUMULATIVE EFFECTS OF WIND FARMS IN THE DUTCH NORTH SEA ON BIRD POPULATIONS

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Abstract

Over the coming years, investigations into whether more opportunities for the development of offshore wind energy exist in the Dutch part of the North Sea will be carried out. This will add to the two offshore wind farms already in operation; OWEZ and Princess Amalia. The overall effect of these future wind farms may have an impact on bird populations.

In order to assess the potential impacts of further wind farms on bird populations within the Dutch sector of the North Sea, a two-step modelling approach was applied. Step one involved constructing matrix-based population models for bird species occurring within the Dutch North Sea. Bird populations included both seabirds and coastal species breeding on the Dutch coast, as well as key passage migrants from populations further away, mainly the coastal areas bordering the international North Sea and further north. This was done for Dutch national populations as well as for international populations on a large regional scale.

Step two involved assessing the ability of the populations to sustain changes in increased mortality. Two wind farm scenarios were modelled in order to provide estimates of the potential mortality due to collisions (which was considered to have a far greater influence on mortality than disturbance or barrier effects in the specific Dutch situation). This additional mortality was applied to the population models and for those species that are stable or increasing the influence of this additional mortality was very limited. For the species with currently declining populations, like Bewick's swan and herring gull, the additional mortality contributed further to these declines. For herring gull, the level of additional wind farm associated mortality was within the limit of Potential Biological Removal (PBR). This study was commissioned by ‘Noordzeewind’ (a joint venture of Nuon and Shell Wind Energy).

AUTOMATED IN SITU MONITORING OF MIGRATORY BIRDS AT GERMANY'S FIRST OFFSHORE WIND FARM

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Abstract

Offshore wind farms may negatively affect migrating birds, especially at night, by increased phototactic attraction and risk of collision. Under favourable weather conditions (clear skies, tail wind) the majority of migrants probably fly well above the reach of wind turbine blades. Under unfavourable conditions (sea fog, precipitation, head wind), however, nocturnal migrants could get attracted by brightly lit wind farms, and the risk of collision would hence increase. To assess these potential effects, migration rates and collision probabilities need to be empirically quantified at existing wind farms. This is not an easy task, given the setting and dimension of an offshore wind farm and the sheer quantity and diversity of small-bodied birds potentially passing by. Nocturnal passerine migrants are impossible to count accurately over extended periods with observational methods, and even classic radar technology fails to provide hard-wired information. Complementing the „Standards for Environmental Impact Assessment“ issued by Germany’s Federal Maritime and Hydrographic Agency (BSH), we have developed and installed a novel radar system (BirdScan) on the research platform FINO 1, situated around 50 km offshore next to the wind farm “alpha ventus” in the German North Sea. BirdScan operates on the basis of defined detection volumes (fixed radar beam), allowing a precise quantification of passerine and non-passerine radar echoes. Our study design includes alternating measurements within and outside the wind farm in order to assess avoidance and/or phototactic aggregation behaviour of migrants under various weather situations. At the same time, we are investigating the phototactic attraction of birds at a smaller spatial scale using motion-controlled infrared cameras directly mounted on the nacelle and shaft of a wind turbine. Through this approach, disoriented birds (and even bats) can be automatically ground-proofed and set in relation to the overall migration volume detected by radar in the vicinity of the wind farm. Funded by Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

METHODS DEVELOPMENT FOR COST-EFFECTIVE MARINE ENVIRONMENTAL MONITORING AT OFFSHORE WIND FARMS IN NORWEGIAN WATERS

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Abstract

Current understanding of the environmental impact from offshore wind farms and experiences in monitoring practices, are restricted to soft-bottom habitats. Due to the large expansion of this source of energy, and the national and international drive to place large parks offshore, there is at present a strong need to further increase our knowledge of the impact on the marine environment in a wider range of habitats. At a national level, it is of importance to develop monitoring methods that are suitable for Norwegian sites and that are adjusted to impact levels expected from wind parks. Biological data on the impact of offshore wind farms in marine ecosystems are predominantly focused on the southern Baltic and southern North Sea. It is shown that large wind farms do have an impact on the marine ecosystem. The most studied effects relate to the introduction of hard substrate (the turbine foundation and scour protection) in an area made exclusively of soft sediments. This leads to an introduction of a new category of fauna, a higher productivity and a shift in community structure and species composition. In addition, the construction of an offshore wind farm excludes other activities with potentially high negative impacts on the marine ecosystem such as bottom trawling. These findings are not necessary applicable to rocky shorelines such as those bordering the Norwegian coast and the first full-scale offshore wind farm, Havsul 1. The Havsul site borders an open ocean with high average yearly wind-speeds of more than 20 knots. A relatively narrow shelf and steep underwater topography creates waves of substantial heights and a benthic marine ecosystem that is fundamentally different from the shallow water, soft sediment substrates in the southern Baltic and North Seas. Instead, areas in Norway with water depths suitable for today's design of offshore wind farms (down to a depth of about 30-50 m) have a complex topography and a mosaic of substrate types are present (rocky seabed, sand, gravel and stones) and are often exposed to severe waves and strong tidal currents. Keystone organisms at an exposed and complex hard bottom environment can potentially include large kelp species (*Laminaria*), red algae growing on bare rock (e.g. *Lithothamnion*) and reef or bed forming species such as the horse mussel (*Modiolus modiolus*) and maerl (coralline algae). These structure-forming organisms support a high diversity of marine life and provide important ecosystem services such as feeding grounds for commercially valuable fish and crayfish species. No studies have so far investigated the effects from large-scale offshore wind farms in this type of environment. The first year of benthic marine baseline data collection in the Havsul area, suggested that there is a lack of standards for monitoring methods at complex marine habitats dominated by bare rock, and kelp communities. We have applied a suite of methods chosen to detect changes in a range of habitats and trophic levels including traditional sediment coring, metagenomic diversity estimates, video data collection and assessment of the kelp community. Preliminary results suggest that it is necessary to adjust monitoring practises to the local environment. This makes comparisons with other regions difficult and may jeopardise efforts to conduct studies of potential cumulative impacts. Benthic community structure assessments and large scale habitat mapping based on video mosaic data is particularly promising both in terms of cost effective collection of data, data quality and sensitivity.

ID STAT: INNOVATIVE TECHNOLOGY FOR ASSESSING WILDLIFE COLLISIONS WITH WIND TURBINES

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Abstract

Assessing wildlife mortality resulting from collision with wind turbines is a recurring concern for conservationists and governmental agencies around the world. Monitoring wildlife fatality is often based on carcass searches below the turbines. However, the efficiency of this technique is known to have many biases, or even be unfeasible in some areas (e.g. offshore wind farms and heavily vegetated environments). To solve this problem, we have developed a system that uses specifically-designed microphones placed within turbine blades to record individual collisions of birds or bats with the blades. The accompanying data loggers contain software that uses acoustical signatures to filter noises produced by the shock on the blade by birds and bats (down to 2.5 grams), from those produced by other objects (rain drops, insects, mechanical noises, etc.). Every time a collision occurs, the system automatically sends the information (sensor ID and turbine, time, etc.) to a remotely located server. Collision can be signalled instantaneously on a cell phone so a ground search can be done soon after the collision under the turbine where the event occurred. After field validation, the system will ultimately allow for quantification of mortality in areas that were previously inaccessible (e.g. offshore wind farms) and the standardization of mortality data collection across wide geographic areas. The remote monitoring capabilities of the system will also allow for low-cost, accurate, long-term mortality monitoring.

STUDYING WILDLIFE AND WIND POWER – PROS AND CONS OF METHODOLOGIES

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Abstract

In recent years, environmental impact studies of wildlife and wind power have increased in abundance. From the simplest visual observation of bird-wind farm collisions to high-tech remote technologies like radar and satellite tags have been applied in the search of the truth about positive and negative effects on wildlife from these turbines. This talk will present the pros and cons of the various methodologies, the state of the art of methods used so far and the potential areas for novel methodological developments for the near future.

TESTING THE EFFECTS OF AN ACOUSTIC HARASSMENT DEVICE ON THE BEHAVIOUR OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*)

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Abstract

The use of monopile foundations for offshore wind farm construction goes along with considerable underwater noise emissions during pile driving, which can potentially harm marine mammals in the vicinity of the sound source. In order to avoid hearing damage in porpoises and seals the use of deterring devices is mandatory during pile driving in German waters. However, so far there is too little information to judge if the deterring effect is sufficient to prevent physical damage in these marine mammals.
Using a combination of visual observations and passive acoustic monitoring (C-PODs) we investigated the spatial effects of a Lofitech seal scarer on harbour porpoises. The seal scarer emits pulses at 14 kHz at a source level of about 189dB re 1 µPa, and sound measurements at various distances where carried out. Sighting rates of porpoises significantly declined within the whole 1 km observation radius. Recordings of porpoise echolocation signals by C-PODs were significantly reduced out to a distance of 7 km, with the strongest effect at the nearest PODs and a weak effect at further distances. Minimum observed approach distance during 28 hours of seal scarer activity was 700 m. A response study revealed clear avoidance reactions by porpoises out to the maximum studied distance of 2.6 km. However, in some cases no reaction was found, and occasionally porpoises were also recorded by PODs at close distances. This shows that there may be substantial variation between individuals, different motivational states or different environmental conditions. These results show that the application of seal scarers is useful for reducing the number of harbour porpoises that may suffer hearing damage caused by pile driving. However, since complete exclusion of all animals cannot be achieved, alternative mitigation measures should be considered.

FIELD SCALE EXPERIMENTS TO ASSESS THE EFFECTS OF OFFSHORE WIND FARMS ON MARINE ORGANISMS

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Abstract

There are different phases in the life of an Offshore Wind Farm (OWF) that need to be considered in terms of how it interacts with the coastal ecosystem: the survey and construction, operation and decommissioning. Taking these phases and identifying the associated effectors and whether they have an effect on coastal organisms is an important step before going on to determine whether actual impact may occur. Hence, we have developed studies focussing first on assessing the effects on species individuals at an appropriate scale and, subsequently looking at the effect across multiple individuals which could then be used to assess effects at the level of the population, thereby providing evidence for an impact (either positive or negative). To obtain ecologically relevant results at a scale appropriate for OWFs, we have taken the experimental approach, incorporating a treatment and control, into the coastal environment using large underwater netted structures (mesocosms) to provide a more realistic setting. To date, our studies have used the mesocosm approach to increase understanding of two relatively unknown effectors on fish: underwater pile-driving noise (Construction Phase) and Electromagnetic Fields (EMF), associated with the production of the electricity by OWFs (Operational Phase). The approach presented here clearly demonstrates that specific effects of OWFs on fish (and potentially other marine organisms) can be determined at a scale that is ecologically relevant. Furthermore, it that provides an important step in assessing what effectors need to be considered in terms of their possible impacts, thereby moving the research agenda forward whilst also meeting the needs of the stakeholders involved with OWF.

NEW TECHNOLOGIES FOR OFFSHORE WILDLIFE RISK STUDIES

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Abstract

Two research initiatives by Pandion Systems, funded by the US Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE), are addressing the enormous challenges of conducting offshore wind-wildlife risk/impact studies by providing new wildlife sensing technologies that surmount some of the limitations of previous techniques. Both initiatives rest on the shoulders of pioneering European studies and experience. One entails the development of a remote-operating acoustic/thermographic detector. This device, designed with input from the Danish National Environmental Research Institute (NERI) and Cornell Laboratory of Ornithology (CLO), will provide species-specific occurrence data, as well as flight altitude estimation, for vocalizing flying wildlife that flies within a detection beam that corresponds roughly to the rotor swept zone of a single, commercial marine wind turbine. While the detection beam is small and limitations exist for silently flying animals, this device will be capable of providing information on bats and on federally-listed bird species that has been difficult or impossible to achieve with other methods. A preliminary version of this device was developed in 2009-2010 in a BOEMRE-funded pilot study, and a sea-worthy device is currently being developed, scheduled for initial deployment on the US Atlantic Outer Continental Shelf (AOCS) in summer, 2011. A second initiative is targeted at developing a high-definition aerial survey protocol capable of providing a safe, cost-effective, reproducible snapshot of bird, marine mammal, and sea turtle distribution on the entire AOCS. This research, being conducted with a team of technologists and biologists including scientists from the British Trust for Ornithology (BTO), entails conducting a series of pilot experiments in spring, 2011 with a variety of different aircraft, cameras, flight altitudes, and image resolutions, to determine optimum protocols for the large-scale surveys. Both of these technologies will provide essential building blocks for ecologically-responsible offshore wind facility development in the US.

IMPACTS ON DEMERSAL FISH COMMUNITIES IN THE NORTH SEA BASED UPON DATA FROM THE FIRST GERMAN OFFSHORE WIND FARM

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Abstract

We investigated potential impacts of wind farm construction on fish communities in the area of the first German offshore wind farm in the North Sea. We also evaluated the fishing methods implemented in the „Standards for Environmental Impact Assessment“ (StUK 3) published by the Federal Maritime and Hydrographic Agency of Germany (BSH). Results of this investigation shall serve as a benchmark for all further investigations during wind farm construction in German sea areas. The methods that we employed were gill-net-fishing (during construction) and beam-trawl-fishing (area-based investigation). Results were compared with previous status quo data on species composition in order to detect changes in fish community structure. At the same time, we investigated fish stocks in an unaffected reference area with similar habitat attributes. First results suggest that some fish species avoided the wind farm due to disturbance through running wind turbines. The main negative influences of wind turbines on fish are likely to be (a) acoustic noise and vibrations by the turbine itself and (b) electromagnetic radiation of underwater cable connections. These influences may result in the disturbance of resident fish species and act as barriers to migrating fish. Additional impacts may arise through the introduction of artificial substrates, which, however, could have positive effects on fish biodiversity, abundances and biomass. Our results may help to re-evaluate potential environmental impacts caused by increasing wind power generation (>6 MW), which could indirectly affects fish communities. We recommend that cumulative effects of the all planned offshore wind farms in Europe should be taken into account in environmental risk assessment protocols.

BEHAVIOUR AND TURBINE AVOIDANCE RATES OF EAGLES AT TWO WIND FARMS IN TASMANIA, AUSTRALIA

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Abstract

The interaction between eagles and wind turbines is often of interest because some species are listed as threatened, there is frequently community interest in eagles, and they are thought to be susceptible to collisions. However, there is little information available on eagle interactions with turbines or their avoidance rates, and none for Australian species. Collision risk modelling requires the input of avoidance rates, however if erroneously high avoidance rates are used, collision risk could be under-estimated.

This study aimed to quantify the avoidance rates of two species of eagle (Tasmanian wedge-tailed eagle *Aquila audax fleayi*, and white-bellied sea-eagle *Halieeatus leucogaster*), and describe how they interacted with wind turbines. Eagle observational studies were conducted at three wind farms in Tasmania, Australia. The Musselroe Wind Farm, north-east Tasmania, was a Greenfield site (approved for development, but not constructed) and acted as a control; Studland Bay Wind Farm, north-west Tasmania, (25 V90 turbines, with 45m blades, 80m tower), had data collected during the construction/commissioning and operation stages; and the Bluff Point Wind Farm, three km north of Studland Bay (37 V66 turbines, with 33m blades, 60m tower) which was operational at the time of the study.

Observers documented flight tracks and behaviour of eagles during 2006 – 2008. An avoidance rate of the turbine tower and an Effective Avoidance Rate (EAR) of the total turbine were calculated. In the majority of cases eagles actively avoided turbines (EAR 90-94%), and rates were consistent between species at the operational site, but lower at the construction/commissioning site. This study revealed that the interaction between eagles and wind turbines is complex, and that management programs and studies that focus on the failure of this avoidance behaviour are likely to be beneficial in trying to determine strategies to reduce eagle collision risk.

EXPANDING FATALITY ESTIMATES FROM THE SEARCH PLOT TO THE ENTIRE SITE

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Abstract

Simple counts of carcasses found at wind farms do not reflect actual fatality because of detection bias. Two commonly recognized sources of bias are carcass removal by scavengers and imperfect detection of remaining carcasses by searchers. There are at least two other sources of imperfect detection: 1) the search plot does not comprise all of the fatalities associated with a turbine and 2) often only a portion of the designated area of the search plot is accessible. Ignoring the fatalities that land outside the search plots will lead to an underestimate of fatality. For carcasses landing within the limits of the search plots, adjusting fatality estimates by a simple measure of the proportion of the plot searched, without accounting for changes in carcass density throughout the plot will likely lead to overestimates of fatality. I propose a method of estimating the detection bias resulting from these two additional sources based on models of carcass density. I test these models at two sites: Locust Ridge, PA and Casselman, PA. Accurate, unbiased fatality estimates are critical to assessing curtailment and deterrent strategies and are fundamental to understanding acute and cumulative impacts of wind power on wildlife populations. Failing to properly correct for imperfect detection of carcasses will lead to biased estimates and inappropriate inference regarding fatality impacts.

MODELING HABITAT DISTRIBUTIONS OF BATS USING GIS: WIND ENERGY AND INDIANA BATS.

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Abstract

Post-construction monitoring indicates that commercial wind energy facilities are a source of bat mortality resulting from collisions or other negative interactions with operational turbines. An understanding of the potential distribution and movement of bats on the landscape is essential to minimizing these impacts. Using remote sensing and Geographic Information Systems software, we present a modelling approach that evaluates the distribution of bat roosting and foraging habitat and potential flight paths at a landscape scale which may be used to assess the risk to bats from the development of a wind energy facility. Accurate assessment of these risks can minimize schedule delays and unexpected costs. Applied to the behaviour and ecology of the United States federally endangered Indiana bat (*Myotis sodalis*) at two hypothetical wind farms, this method predicts the areas where the species is likely to travel while foraging, thereby highlighting the riskiest areas within a project area. The results of our modelling indicate that risk to bats is not directly proportional to habitat availability or suitability, in part because risk is associated with areas where bats are travelling. This modelling approach will assist wind energy developers in making both large-scale (e.g., choosing between different development locations) and small-scale decisions (e.g., choosing where to locate turbines) aimed at minimizing impacts to bats. Using habitat models can provide a cost-effective method for evaluating bat risk, satisfying requirements of regulatory agencies, and limiting the more intensive survey methods to projects that absolutely require them.

ASSESSING THE IMPACT ON BIRDS OF PREY OF NINE ESTABLISHED WIND FARMS IN THRACE, NE GREECE

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Abstract

In this study, we evaluate the impact on birds of prey of nine already established wind farms in Thrace, where a large scale wind farm development project of at least 930 MW is under development. Moreover, the area is acknowledged as of high ornithological interest, used for nesting, wintering and passage by rare territorial birds of prey, including the Near Threatened black vultures that use it for foraging. Finally, ca 50% of the wind farm development project area is covered by Natura 2000 sites.
During the monitoring (2008-2010), carcass surveys were carried out in order to estimate mortality. In addition, avian space use surveys were carried out, in order to calculate indexes and to establish comparisons with a previous monitoring study run in 2004-05.
In total, 14 birds of prey were found dead (one black vulture, four griffon vultures, one booted eagle, two short-toed eagles, one western marsh harrier, one Eurasian sparrowhawk, three common buzzards, one hawk species). The estimated mortality rate was 0.152 birds of prey (including vultures/turbine/year). Griffon vultures, black vultures and common buzzards comprised more than 50% of observations in the study area. Crossing densities between wind turbines were positively correlated with east exposition and the inclination of the slope, and the length of the wind turbines' gaps, while it was negatively correlated with north exposition. The use of the area was more intensive four years after the initial monitoring, but numbers of common buzzard observations drastically decreased.
We suggest that during the planning phase of wind farms it is important to avoid steep slopes, east expositions and to take into account the distance between consecutive wind turbines. Our findings indicate that running a post-construction monitoring during only one year may not be enough to properly assess the impact of wind farms on birds of prey.

FLIGHT PATTERNS OF BIRDS IN AN OFFSHORE WIND FARM IN THE NETHERLANDS

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Abstract

Flight patterns of birds were studied in the framework of a three-year effect-study in the Dutch Offshore Wind Farm Egmond aan Zee, following a two-year baseline study. Both visual and continuous radar observations were carried out between 2007 and 2010, to assess fluxes, flight altitudes and deflection of flight paths. Visual observations provided information at species level. A horizontal and a vertical radar that were equipped with Merlin (DeTect Inc.) for automated data recording and processing, provided continuous data on flight paths, including data during night time and adverse weather.

We show results on flight paths, fluxes and flight altitudes that were recorded using radar. Flight paths, being flight directions and routes through the wind farm area, were studied to assess the occurrence of deflection. Fluxes and flight altitudes were studied to quantify the number of birds at risk from collision with the turbines.

Flight paths of many different species were registered visually. Interspecific variation in reactions was considerable, while intraspecific variation was low. Reactions of the birds to the wind farm could be separated in four categories. Local birds either did avoid the wind farm (e.g. gannets) or did not (e.g. cormorants attracted to the wind farm from the main land). Similarly, migrant birds either did (e.g. geese) or did not avoid the wind farm (e.g. terns, nocturnal thrushes).

Seasonal and diurnal variations in bird activity were recorded in both flux and flight altitudes from sea level up to 1.5 km. High altitude passages were mainly nocturnal migratory birds including waders and thrushes. Movements during the day at lower altitudes primarily included gulls, cormorants and alcids.

This study was commissioned by ‘Noordzeewind’ (a joint venture of Nuon and Shell Wind Energy).

OPTIONS FOR MITIGATION OF BIRD COLLISIONS AT OFFSHORE WIND FARMS: A EUROPEAN PERSPECTIVE

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Abstract

Lighted tall offshore constructions cause mortality by collisions especially in nocturnally migrating passerine birds. Based on recent investigations and modelling approaches evidence is provided that thousands of offshore wind turbines in the Baltic and North Sea will probably cause cumulative hazardous effects on Scandinavian birds at a population level, especially if populations are declining. Similar risks can be assumed for other high concentration areas of nocturnal bird migration in the Mediterranean. Irrespective of the need for a scientific evaluation of the significance of the potential environmental impact, which is likely to occur on a European level, first technical solutions have been evaluated in recent years to reduce the amount of traffic safety lights. Even though such technical solutions (i.e. intelligent radar transponders) would be generally available, the implementation of new international rules for aids for navigation (in ideal: “switch on/off light on duty”) will require extensive risk assessments both at national and international level as well as further technical developments. “Switch off turbines on duty” is another intensively discussed mitigation measure if bird collision risk is considered. However, switching off the turbines of an offshore wind farm will not affect only a single wind farm but up to several hundred or thousand turbines at a time within a certain collision risk region. Thus, such a mitigation measure will require a robust large-scale forecasting and evaluation tool together with the co-operation of several wind farm operators for successful implementation. Recent technical progress would allow for such a development. Only four tools will be required: (1) a pre-warning model (several national bird migration models already exist for bird strike prevention in aviation), (2) a large scale real time analysis of nocturnal bird migration by means of weather radar (a European network of weather radar operators exists, real time analysis of bird migration intensity is available), (3) a local real time evaluation of low altitude nocturnal bird migration by means of fixed beam radar, and (4) a local real time analysis of bird attraction in the vicinity of turbines by video tracking systems (both technologies are proven, but require the implementation of real time analysis). The combination of these tools would provide operators sufficient time for grid stabilization measures prior to a potential operational break-down. Furthermore, the local real time evaluation would allow for minimization of a realized break-down in time and space together with the avoidance of expensive false alarms.

AEROECOLOGY: AN EMERGING FRONTIER

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Abstract

Aeroecology is an emerging discipline that embraces and integrates the domains of atmospheric science, ecology, earth science, geography, computer science, computational biology, and engineering. The unifying concept that underlies this discipline is its focus on the planetary boundary layer, or aerosphere, and the myriad organisms that, in large part, depend upon this environment for their existence. The aerosphere influences both daily and seasonal movements of organisms, and its effects have both short- and long-term consequences for species that use this fluid environment. The biotic interactions and physical conditions in the aerosphere represent important selection pressures that influence traits such as size and shape of organisms, which in turn facilitate both passive and active displacements. The aerosphere also influences the evolution of behavioural, sensory, metabolic, and respiratory functions of organisms. In contrast to organisms that depend strictly on a terrestrial or aquatic existence, those that routinely use the aerosphere are almost immediately influenced by changing atmospheric conditions (e.g., winds, air density, precipitation, air temperature), sunlight, polarized light, moon light, and geomagnetic and gravitational forces. The aerosphere has direct and indirect effects on organisms, which often are more strongly influenced than those that spend significant amounts of time on land or in water. Future advances in aeroecology will be made when research conducted by biologists is more fully integrated across temporal and spatial scales in concert with advances made by atmospheric scientists and ecological modelers. Ultimately, understanding how organisms such as arthropods, birds, and bats aloft are influenced by a dynamic aerosphere will be of importance for assessing, and maintaining ecosystem health, human health, and biodiversity.

BIRDS AND WIND ENERGY

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Abstract

Climate change, perhaps more accurately described as climate disruption, is considered to be a major long-term threat to biodiversity, with a high probability that the underlying cause is due to anthropogenic greenhouse gas emissions. Renewable energy is an important component of a programme of measures to combat further climate change, to include improved energy efficiency and demand management. Wind energy is the most advanced renewable energy source and is a global industry onshore and, increasingly, offshore. However, as with any form of energy generation, wind energy also has potential environmental costs which have to be balanced against benefits.

The environmental impacts on birds derive from the following: collision risk, in particular from the moving rotor blades; displacement arising from disturbance during construction, operation or decommissioning; habitat loss or change leading to alteration of food availability; barrier effects leading to deviation of long distance migratory flights or disruption of local flights between feeding, nesting, and roosting/loafing locations. Not all species of birds, or individuals within a species, are equally susceptible to negative interactions with wind turbines, and neither are the population consequences of impacts equivalent.

Of greatest concern are bird species of conservation concern that exhibit behaviours that place them at risk of an adverse impact, notably when that impact leads to a reduction in population size that is unlikely to be compensated for. In particular, cumulative impacts arising from multiple wind farms or wind farms in combination with other developments are of concern. There has been a welcome increase in research effort and peer-reviewed publications on the subject of birds and wind energy in recent years. Increasing our understanding of impacts is essential to delivering possible solutions and this paper reviews current knowledge for birds.

USING DNA ANALYSIS TO ASSESS TERRITORY STRUCTURE, MORTALITY AND PARTNER SHIFTS IN A POPULATION OF WHITE-TAILED EAGLE BREEDING INSIDE AND CLOSE TO THE SMØLA WIND-POWER PLANT

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Abstract

In this project, we used DNA analyses for individual identification of the population of white-tailed eagles at Smøla. Our objective was to follow the adult birds over time and reveal mortality and partner shifts at the nesting sites. Moulted feathers from adult eagles and plucked feathers from chicks were collected yearly over a five-year period (2006-2010) from all known eagle territories on Smøla, both within and outside the wind-power plant area. In addition, tissue samples from all birds that died in collisions with the wind turbines were collected. Altogether, feathers from more than 80 nests were sampled during 2006-2010. Our data demonstrated that many of the breeding pairs used several nesting localities, between which they move from one year to another. The 80+ nests in our sample represented 40 active territories, which is close to 100% of the known active territories on Smøla. Our results showed that the number of active white-tailed eagle territories on Smøla had been overestimated from observations by more than 25%. This demonstrates the importance of conducting DNA analysis along with other methods when estimating the breeding population size for birds of prey. So far, we have documented 13 certain instances where one of the birds in a breeding pair has been replaced. In five of these instances, the bird that was replaced was found killed by a wind turbine. Other mortality factors may have influenced the remaining eight replacements. However, a large proportion of the birds with unknown fate had established territories close to the wind-power plant area, suggesting that even these birds might have been fatally injured or killed in collisions with a turbine. An integrated approach combining data from adult birds, chicks on the nests and birds killed by wind turbines is currently used to quantify the survival rate in the adult population and the potential negative effect from the wind power plant.

PROPOSING AN APPROACH FOR THE ASSESSMENT OF ENVIRONMENTAL IMPACTS OF OFFSHORE WIND FARMS IN EUROPE

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Abstract

Analyses of numerous EIS and EIA in the chosen countries, which have been worked out by the authors, have documented that the assessments failed to standardize both the prognosis and the assessment method. The assessment and the relevance of the manifold provided data tends to remain vague and can only hardly been used by the authorizing bodies.
Thus, decision makers need an appropriate, transparent and comparable decision-making 'portfolio' to provide at best bullet-proofed EIA documents, based on a systematic analysis of research results, baseline surveys and a prognosis of the expected impacts. A satisfactory state of research or good practice for the assessment of the environmental impacts, which also enables comparability and cumulative considerations of the impacts of offshore wind farms in an international context, should be reached. A transparent evaluation approach of data for the analysis of the relevant issues therefore was essential. Carrying this in mind the Technische Universität Berlin developed proposals for semi-quantitative assessment models for migratory birds, sea and resting birds and harbour porpoises that, if used within the EIA, could provide the permit requirements more transparent with relevant data and assessments to the necessary decision-making basics.
Because of the differences of impact correlations between the diverse natural assets and the offshore wind farms, individual models have been developed for several impact correlations, which have been identified as especially significant for the real decision making process. The numerous influencing factors of each impact therefore have been compiled. With the elaborated models these factors are linked systematically. The obtained data can be used for a comparison with the social given objectives (in form of legal thresholds). Therefore the presented models have to be established inside the EIS as well as in the approval system. So it could bring advantages in the comparability of the impact potential of different offshore wind farms through the quantitative assessment of the impacts.

THE CHALLENGE OF CUMULATIVE IMPACTS

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Abstract

As governments pledge to combat climate change, wind turbines are becoming a common feature of terrestrial and marine environments. Although wind power is a renewable energy source and a means of reducing carbon emissions, there is a need to ensure that the wind farms themselves do not damage the environment. There is particular concern over the impacts of wind farms on bird populations, and with increasing numbers of wind farm proposals, the concern focuses on cumulative impacts. Individually, a wind farm, or indeed any activity/action, may have minor effects on the environment, but collectively these may be significant, potentially greater than the sum of the individual parts acting alone.
Cumulative impact assessment is a legislative requirement of environmental impact assessment but such assessments are rarely adequate restricting the acquisition of basic knowledge about the cumulative impacts of wind farms on bird populations. Reasons for this are numerous but a recurring theme is the lack of clear definitions and guidance on how to perform cumulative assessments. Here we present a conceptual framework and include illustrative examples to demonstrate how the framework can be used to improve the planning and execution of cumulative impact assessments. The core concept is that explicit definitions of impacts, actions and scales of assessment are required to reduce uncertainty in the process of assessment and improve communication between stakeholders. Only when it is clear what has been included within a cumulative assessment, is it possible to make comparisons between developments. Our framework requires improved legislative guidance on the actions to include in assessments, and advice on the appropriate baselines against which to assess impacts. Cumulative impacts are currently considered on restricted scales (spatial and temporal) relating to individual development assessments. We propose that benefits would be gained from elevating cumulative impact assessments to a strategic level, as a component of spatially explicit planning.

MODELLING SEABIRD COLLISION RISK WITH OFF-SHORE WIND FARMS

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Abstract

Recent concern about the adverse effects of collision mortality of avian migrants at wind farms has highlighted the need to understand bird-wind turbine interactions. Here, a stochastic collision model, based on data of seabird behaviour collected on- site, is presented, as a flexible and easy to take tool to assess the collisions probabilities of off-shore wind farms in a pre-construction phase.

The collision prediction model considering the wind farm area as a risk window has been constructed as a stochastic model for avian migrants, based on Monte Carlo simulation. The model calculates the probable number of birds collided per time unit. Migration volume, wind farm dimensions, vertical and horizontal distribution of the migratory passage, flight direction and avoidance rates, between other variables, are taken into account in different steps of the model as the input variables. In order to assess the weighted importance of these factors on collision probability predictions, collision probabilities obtained from the set of scenarios resulting from the different combinations of the input variables were modelled by using Generalised Additive Models.

The application of this model to a hypothetical project for erecting a wind farm at the Strait of Gibraltar showed that collision probability, and consequently mortality rates, strongly depend on the values of the avoidance rates taken into account, and the distribution of birds into the different altitude layers. These parameters should be considered as priorities to be addressed in post-construction studies.

THE EFFECTIVENESS OF SEARCH DOGS COMPARED WITH HUMANS IN SEARCHING DIFFICULT TERRAIN AT TURBINE SITES FOR BAT FATALITIES

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Abstract

Many wind farms in the UK and elsewhere in northern Europe are situated in habitat with dense tall vegetation such as arable fields and upland heaths. This makes surveying for bat fatalities extremely difficult. To facilitate a multi-centre study of the effects of wind turbines on British bats, we have therefore conducted controlled trials of the relative success of trained search dogs and ecologists in retrieving bat carcasses. Although dogs have been used previously in ecological surveys for bats, this is the first time they have been specifically trained for use in “difficult to survey” habitats. Two ecologists and two Labrador dogs with handlers were each given the opportunity to retrieve up to 45 bat carcasses in a range of habitat types. Their efficiency in terms of overall search time, costs, and retrieval abilities were evaluated. Our results indicate that high rates of retrieval can be achieved by dogs, even in dense vegetation up to 75cm high. Further, a typical 100m2 search area can be surveyed in less than half the time taken by humans. The limitations of using search dogs, and their ability to detect the presence of bats that have been scavenged are also presented (presentation supported with video footage).

COLLISION RISK IN WHITE-TAILED EAGLES – AVOIDING RISKY MODELLING

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Abstract

Energy from renewable sources has become increasingly important as part of energy policies worldwide. Energy and environmental management authorities, and the energy industry, have stressed the need for additional knowledge about environmental impacts of wind turbines. Impacts may be due to direct collision mortality caused by wind turbines, which in turn may be mediated by avoidance behaviour. Since 2005, 38 white-tailed eagles (*Haliaeetus albicilla*) have collided with wind turbines at the Smøla onshore wind-power plant in central Norway. Here we aim to elucidate the extent of collision risk and avoidance in eagles on Smøla. Based on vantage point data the expected collision risk, and associated correction factor, was estimated using the Band-model. This correction factor is often thought to be related to displacement and avoidance. The effect on model outputs of varying the number of hours' input data has not been tested, and how this varies with spatial variation in activity. There are also unquantified sources of error associated with the collection and analysis of the underlying data which may tend to reduce the magnitude of estimated mortality. This includes field-collected data based on point-counts to estimate flight activity within a particular radial sector, and yet distance sampling is not used to correct for any likely fall-off in detectability with distance. Also, the focal sampling method may reduce the overall estimate of activity, and estimates of avoidance are largely unquantified. We therefore propose a method which makes use of the data delivered by the birds themselves, through the use of three-dimensional GPS satellite telemetry data from 27 sub-adult eagles equipped with backpack transmitters. We constructed a statistical simulation model using Brownian bridge methodology for estimating collision risk rates. Eagles showed clear seasonal and spatial patterns in collision risk rates. Our results may provide industry and management authorities with new tools for assessing the extent of collision risks of wind energy structures.

RAPTOR MORTALITY IN WIND FARMS OF SOUTHERN SPAIN: MITIGATION MEASURES ON A MAJOR MIGRATION BOTTLENECK AREA

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Abstract

To assess and monitor the impact of wind farms on fauna is crucial if we want to achieve ecologically sustainable development of this renewable energy resource. Today there are clear evidences that the probability of raptor collision depends critically on species behaviour and weather conditions, and the topographic factors related to each windmill. In our study area EIA were not able to predict this differential risk and in these circumstances mitigating the causes of bird mortality becomes a task of major importance, especially to those wind farms located in the Strait of Gibraltar, a water crossing of 14 km at its shortest distance acting as a major migration bottleneck for Paleo-African soaring migrants. We collected all available information on raptor collision from 1992, when the first wind farm was installed, and from 2005 until present a total of 262 turbines, grouped into 20 wind farms, were surveyed in a daily basis through a surveillance program with the main goal of register the actual mortality of birds.

A total of 1291 raptors of 19 species were found of which 78.5% correspond to two species, the griffon vulture (*Gyps fulvus*) and the kestrel (*Falco tinnunculus*). In order to mitigate the impact on raptors, and particularly on the griffon vulture, in 2007 a program based on selective stopping of turbines was imposed, in collaboration with the environmental competent authority, on new approved projects. During 2008 there was a reduction in mortality by 48%, which remained in 2009 with a remarkably lower economic cost. An analysis of the temporal collision patterns will be presented and discussed, with special attention to those species suffering higher mortality rate, and to those who have some degree of threat.

EU GUIDELINES ON WIND ENERGY AND NATURE CONSERVATION

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Abstract

The EU has adopted far reaching 'climate change and renewable energy' commitments to cut greenhouse gas emissions, increase the use of renewable energy and cut energy consumption by 2020. It has also ambitious targets to halt and reverse the loss of biodiversity by 2020. The NATURA 2000 ecological network is critical to achieving the biodiversity goals. There can give rise to potential conflicts and there is a need to ensure that development of the wind energy industry is carried out in a sustainable and balanced way that does not lead to significant damage to sensitive areas of conservation importance.

EU guidelines have been developed to help ensure that wind energy developments are compatible with key provisions of the Habitats and Birds Directives (http://ec.europa.eu/environment/nature/natura2000/management/docs/Wind_farms.pdf). The guidelines also promote good practice in relation to location, planning, design, construction and operation of wind farms and their associated infrastructures to minimise their impact on biodiversity.

The guide is designed principally for use by competent authorities and developers, as well as consultants, site managers and other practitioners who are involved in the planning, design, implementation or approval of wind farms plans or projects. It has been prepared with the support of a Working Group consisting of representatives of the wind energy sector, experts, Member States, international environmental organisation and NGOs.

The guide provides an overview of wind energy development in Europe and of the policy framework at EU level. It summarizes the key provisions of the EU's biodiversity policy and the Habitats and Birds Directives. It also explores the relationship between Strategic Environmental Assessments under the SEA Directive, Environmental Impact Assessments under the EIA Directive and Appropriate Assessments under the Habitats Directive. Based on a review of existing scientific literature and other sources of information it assesses the potential risk to species and habitats from wind energy developments. It examines the benefits of strategic planning for wind farm developments as a means to achieving a more efficient and integrated decision-making process that helps to avoid or minimize conflicts later on at the project level. Finally, it provides advice and guidance on how to carry out an Appropriate Assessment for wind farm developments that may affect Natura 2000 sites.

The guidance document includes the following key messages. Whereas wind energy in general does not represent a serious threat to wildlife, poorly sited or designed wind farms can pose a potential threat to vulnerable species and habitats, including those protected under the Habitats and Birds Directives. There is not, a priori, prohibition of wind farm developments in or adjacent to Natura 2000 sites. These need to be judged on a case by case basis. Planning wind farm developments in a strategic manner over a broad geographical area is the most effective means of minimising impacts of wind farms on nature and wildlife. It not only leads to a more integrated development framework but reduces the risk of difficulties and delays later on – e.g. at level of individual projects. There is also a need for good quality project environmental assessments. Measurement of significance of effects needs to be assessed in the context of the conservation objectives of the areas concerned. An assessment must be based on sound science to allow for the risks to be appropriately evaluated.

MANAGING HABITAT FOR PREY RECOVERY – AN OFF-SITE MITIGATION TOOL FOR WIND FARMS' IMPACTS ON TOP AVIAN PREDATORS

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Abstract

Several studies reveal that wind farms (WF) have a negative impact on avian communities, pointing raptors as one of the vertebrate groups most affected. It has also been verified that top avian predators are attracted to areas of high prey densities and that risk increases when high number of preys occur in the vicinities of WF. In some studies, the reduction of common preys inside the WF area has been proposed as a mitigation measure.
In the Mediterranean ecosystem the wild rabbit (*Oryctolagus cuniculus*) is a key species playing a vital role as a prey for a wide spectrum of endangered top predators, like golden eagle (*Aquila chrysaetos*). Unfortunately, in Portugal wild rabbit populations have declined dramatically and the species is now considered as "Near Threatened".
In this context, the reduction of rabbit populations is not a desirable mitigation option, being more advantageous the promotion of these populations in areas inside eagles' home range, but relatively far away from the WF. This measure might mitigate the negative impact by promoting the change of eagles' core areas and compensate the mortality by improving eagles' survival and annual productivity.
These measures were tested in Northern Portugal during three years, in order to compensate the impact of a power line in two golden eagle couples. Efforts to restore wild rabbit populations were applied in two study areas and focused upon habitat management. To evaluate the management scheme, we monitored rabbit populations in managed and control areas by pellet counts, and the eagle couples through field observations and satellite telemetry.
A Hurdle Model was used to test the abundance of rabbit populations, which was significantly higher in managed areas in relation to control areas. Both eagle couples intensely used managed areas and during our study there was a low use of power line vicinity area. Based on the success of this case study we are starting now applying this technique to a wind farm project.

MORTALITY OF RADIO COLLARED WILLOW PTARMIGAN IN SMØLA WIND-POWER PLANT

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Abstract

In the project Pre- and post-construction studies of conflicts between birds and wind turbines in coastal Norway (BirdWind), Smøla willow ptarmigan (*Lagopus lagopus variegatus*) has been one of the species studied. This sub-species represent gallinaceous birds, known to be bad flyers susceptible to collide with artificial structures, e.g. power lines. However, the possible impact of a wind-power plant on survival and behaviour in a willow ptarmigan population was unknown.

The objectives of the study were therefore rather wide; to study direct and indirect effects of wind turbines on willow ptarmigan behaviour, habitat selection, reproduction and survival in areas where wind-power plants are established.

To collect data on habitat selection, movements, collision risks, avoidance behaviour, survival and general population dynamic parameters, willow ptarmigan were radio-tagged in 2008-2010, using traditional VHF-transmitters (Holohill) with mortality switch, necklace mount, 12 g, lasting for approximately 24 months. Due to low population density and only occasional snow cover, a method using strong lights, dipnet and car was used to catch birds. In total, 34 willow ptarmigan were caught (19 males and 15 females).

All birds were caught inside the wind-power plant area (WPA). The birds were radio-tracked at irregular intervals and almost all birds, when found, was located within the WPA. All carcasses of dead birds were examined. When possible, cause of death was determined as; predation (raptor), collision, unknown, other.

In total, 28 of the radio-tagged birds have died since January 2008. A Kaplan-Meier analysis of cumulative survival rates, show an exceptionally low survival (<30%). Unlike other willow ptarmigan populations most of the mortality takes place during winter, from December throughout March. Although a thorough analysis of mortality causes has yet not been carried out, a majority of the birds have probably been killed by avian predators and to a lesser extent by colliding with wind turbines. The high winter mortality coincides with regular visits in the area from raptors on migration from the mainland. However, the effect of the additional mortality caused by collisions with wind turbines on population viability is discussed.

STATISTICAL POWER IN TESTING MARINE FAUNA DISPLACEMENT DUE TO AN OFFSHORE WIND FARM

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Abstract

The design of monitoring programs to detect impacts of offshore wind farms on marine fauna is a complex task. For example, the spatial variability in species abundance at various scales needs to be accounted for and there are also logistic limitations for the data collection at sea. Under the Precautionary Principle, the probability of failing to detect impacts that may be occurring should be minimized. We implement this principle by means of a statistical power analysis and assess the effect of spatial factors on the ability to detect potentially occurring displacement of marine fauna.

Implementation is based on geostatistical simulation of ecological surveys (count data), accommodating spatial variability in species abundance at various scales as well as often encountered zero-inflation in count data. Our analysis allows us to rank the relative importance of different factors that influence our ability to detect impact. The most influential factor is the environmental conditions at the time of the survey, followed by survey effort and species abundance in the reference situation. Spatial autocorrelation in species abundance at local scales is also important, but for the scenarios investigated it only plays a minor role.

Next, we propose a method for calculating the probability of correctly detecting a potential impact after N number of surveys, when for the used spatial survey design the probability of committing errors is known.

Our findings can be used to improve effectiveness of the economical investment for monitoring surveys. Moreover, unnecessary extra survey effort, and related costs, can be avoided when spatial autocorrelation in species abundance is present. Finally, the proposed method supports decisions on the number of surveys that are needed after wind farm construction to improve the detection of impacts possibly occurring.

PRE- AND POST CONSTRUCTION MONITORING AND STAKE HOLDER INVOLVEMENT OF ON-SHORE TURBINES ADJACENT TO SEVERN ESTUARY RAMSAR SITE.

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Abstract

Surveys were conducted in 2004 and winter 2006/07 prior to construction of three Enercon 2MW turbines adjacent to intertidal mudflats on Sever Estuary at Bristol Port in summer 2007. An advisory panel of stakeholders was established to agree and oversee monitoring protocol and production of annual reports, public statements and modification of monitoring protocol. This had representative from the planning authority, Bristol Port, statutory nature conservations organisations, national and local nature conservation NGO's and local wildlife interests. Post construction monitoring included:

- collision watch surveys
- ground searches
- vantage point surveys
- disturbance surveys
- ringed plovers breeding beneath the turbines.

Since construction there has been a reduction in birds flying through the site particularly gulls. An estimated 415,000 birds annually transiting the site but no collisions have been observed or casualties found. The mean count of waterbird species feeding on intertidal mudflats has been between 11%-57% higher than pre construction and the mean count of SPA wildfowl and waders species has been between 55% and 272% higher. Threshold distances for disturbance generally range from 150-300m although some species feed within 100m and roost within 50m of the turbines. Ringed plover continue to nest beneath turbines. The Advisory Panel met numerous times during the first year and despite very different interests in the site and initial views on the turbines has developed a good working relationship and now meet annually.

WIND ENERGY'S SUBTLE EFFECT - HABITAT FRAGMENTATION

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Abstract

New wind energy production facilities are being built to accommodate demands for more, renewable, emission-free energy. This development is most often in windy, remote parts of the United States, so new transmission infrastructure capacity is also needed for shipment of energy from prairies, hilltops and shorelines to distant population centres.
Well known environmental effects from wind energy development have included direct mortality to birds and bats. However, there is a more subtle effect also at play. “Habitat fragmentation” is an impact caused by the siting and presence of infrastructure features on wildlife species. Instead of direct mortality, there is behavioural avoidance of such features because of activity, noise and even simply the presence of vertical structures that are different from the original nature of the habitat. This fragmentation threatens to make some of the last remaining habitat for declining species, especially grassland birds, unusable by them.
Prairie grouse such as prairie chickens and sage grouse appear to be particularly susceptible to habitat fragmentation due to the presence of vertical structures. Other species such as the grasshopper sparrow have also been shown to avoid such features. It is believed that these species have evolved to avoid any vertical structure because it can serve as a perch for bird-eating raptors, including eagles, hawks, falcons and owls. Certain life cycle stages, such as nesting and chick rearing, appear to be most vulnerable to these fragmentation influences.
Some of the research contributing to concern over habitat fragmentation, along with the mechanism of such fragmentation, will be presented. Solutions will also be offered for the siting of wind energy facilities and transmission lines to avoid this negative environmental impact.

WINDTURBINES AND MEADOW BIRDS IN GERMANY – RESULTS OF A 7 YEARS BACI-STUDY AND A LITERATURE REVIEW

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Abstract

In many parts of Germany meadow birds – either breeding or staging – are the species most affected by wind farms planned in open agricultural areas. A 7 year BACI-study (before-after-control-impact) in the south of East Frisia, Lower Saxony, investigated the influence of wind turbines on several meadow bird species. The parameters analysed comprised population trends, spatial distribution and behaviour in relation to turbine distance, breeding success as well as the influence of certain habitat parameters like type of agricultural use and the distance to woods and hedges.
The results show, that breeding birds are generally less sensitive to wind turbines than staging birds. Significant reductions of breeding lapwing density occurred only up to a distance of 100 m. Curlews however showed a reduction of resting and grooming behaviour up to a distance of 250 m. Other species like meadow pipit, skylark and stonechat showed no indications of displacement. An impact of wind turbines on breeding success could not be detected. Breeding lapwings showed a strong preference for certain types of crops, which led to spatial aggregations irrespective of turbine proximity. In staging birds a much more obvious displacement up to about 400 m could be detected.
The results are consistent with a number of other German studies on possible displacement effects in different bird species. Lapwing and skylark are among the best studied species whereas staging geese tend to be the most sensitive ones. In conclusion the siting of wind farms must not only be guided by occurrence of endangered species named on national or regional Red Lists but also by the species-specific sensitivity against the disturbance effects of wind turbines.

THE DEVELOPMENT OF AN AVIAN WIND SENSITIVITY MAP FOR SOUTH AFRICA

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Abstract

Wind energy is a relative new industry in South Africa. This provides South Africans with the opportunity to ensure that wind farms are placed in areas that are of low sensitivity to birds. With this in mind two environmental NGOs, BirdLife South Africa and the Endangered Wildlife Trust, designed an Avian Wind Sensitivity Map to provide guidance to the wind farm industry about the location of wind turbines. The map is the first of its kind in Africa.

The purpose of the map is to provide an indication of the geographic areas in South Africa where the possible establishment of wind farms might have a negative impact on birds. Such a map will identify areas of bird sensitivity, i.e. sites where threatened, endemic and vulnerable bird species occur.

The map was designed using a variety of data sources, specifically data acquired through citizen science projects - such as the Southern African Bird Atlas Project 2 and the Coordinated Waterbird Counts Project. The data were analysed using data priority scores based on the conservation concern of each species as well as the risk associated with a species to fly into wind turbines and associated infrastructures. The formal protection status of a geographic area was also taken into account. Extensive use was made of GIS tools to collate, analyse and present the data.

A number of African countries are considering establishing wind farms. The lessons learnt during the design process can be used by other African countries as the basis for similar maps which can serve as a mitigation measure against the loss of vulnerable species.

EFFECT OF WIND TURBINE MORTALITY ON NOCTULE BATS IN SWEDEN: PREDICTIONS FROM A SIMPLE POPULATION MODEL

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Abstract

The noctule bat *Nyctalus noctula* is apparently the species most seriously affected by wind turbine mortality in northern Europe. It occurs in south Sweden up to about 60oN, although the abundance is much higher in lowland agricultural areas than in forests. We used a recent estimate of 90 000 individuals as the population size in Sweden, and assumed a stable starting population not affected by mortality from wind turbines. In the absence of data from Sweden, we used demographic data and fatality rates at wind turbines (0.9 noctules/turbine/year) obtained in eastern Germany. Population development up to year 2020 was calculated, based on the current estimate of wind farm development in Sweden; ca. 1000 present and 2500 additional turbines within the area of noctule distribution. The results suggest that the additional mortality at wind turbines may affect the noctule bat in Sweden at the population level. However, the effect will probably be small, particularly in comparison with other anthropogenic sources. We are currently using the model to predict the effect on other bat species and birds.

THE EFFECTS OF WIND TURBINES ON WHITE-TAILED EAGLES (HALIAEETUS ALBICILLA) IN HOKKAIDO, JAPAN

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Abstract

The recent growth of wind facilities in Japan has raised concerns about bird collisions, especially for white-tailed eagles in Hokkaido, northern part of Japan. Approx. 150 pairs of white-tailed eagles breed in Hokkaido in the latest survey (Shiraki unpub. data) and these pairs are considered as residents. On the other hand, ca.500-700 white-tailed eagles including migrants from the breeding areas in Russia winter in Hokkaido.

The major objectives of this study are to (1) examine the impacts of wind turbines on white-tailed eagles by information analysis in the previous accident reports of the collisions and by field investigations at the wind facilities, and (2) explore the possible factors which relate to the collisions of the eagles with wind turbines

A total of 24 collisions of sea eagles (*Haliaeetus spp*.) have been reported by both incidental discoveries and fatality searching since 2004 in Hokkaido. 22 of the 24 fatalities were white-tailed eagles and 23 of the 24 were immature birds.

Field surveys to estimate of fatality rate of white-tailed eagles and observations of the flight behaviours were carried out at the wind facilities including a total of 42 turbines for one and half years. Annual mortality for white-tailed eagles was estimated at 0.08 fatalities / yr / MW and the Risk Index (Smallwood & Thelander 2004) was calculated at 0.058, the second highest value after common buzzards (*Buteo buteo*) in this survey. In addition, white-tailed eagles and common buzzards flew at the altitudes of rotor zones of the wind turbines more frequently than the other raptors.

The effects of the collisions at wind turbines on white-tailed eagles in Hokkaido based on the results of this study, and on the ecological and the genetically information of the population will be considered in the presentation.

LINKING TURBINE COLLISION RISKS WITH POPULATION MODELS TO ASSESS CUMULATIVE IMPACTS OF MULTIPLE WIND FARMS ON THREATENED BIRDS

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Abstract

Assessment of the effects on birds of wind turbine collisions has generally been focussed on the number of individuals that might be killed at a particular facility. However, this measure, of itself, may have little relevance to evaluating the potential or real effects on conservation status of threatened species. Determination of the overall effect any such mortality may have on the functioning of these populations will provide a better basis for decisions that have a strong foundation in ecology.

For species with sufficient demographic information, we have developed and applied an approach combining collision risk modelling for all wind farms within the range of a threatened species with population modelling. This permits population-level evaluation of potential cumulative impacts of multiple wind farms.

In Australia, regulatory authorities are increasingly interested in the cumulative risk to threatened species that may be posed by multiple wind energy facilities within a species' range. The approach outlined here has been applied in the pre-construction approval stage using collision risk modelling, and can be applied to operational facilities using data on actual mortalities.

Cumulative modelling of risk posed by multiple wind farms requires different approaches for sedentary and migratory species. For sedentary species the cumulative effect will be the sum of the impact experienced by those parts of the population whose range intersects with wind farms.

Cumulative impact is derived for migratory species by assessing the probability of birds surviving encounters with one wind farm after another on the migratory route and is thus the product of their survivorship rates for the relevant wind farms.

The collision risk modelling used will be outlined along with the method in which it is integrated with a population model. Case studies for a crane (*Brolga Grus rubicundus*) and a parrot (orange- bellied parrot *Neophema chrysogaster*) species will be outlined.

COMPARING AVIAN AND BAT FATALITY RATE ESTIMATES AMONG NORTH AMERICAN WIND ENERGY PROJECTS

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Abstract

Wind energy development has expanded rapidly, and so have concerns over bird and bat impacts caused by wind turbines. To assess and compare impacts due to collisions, investigators use a common metric, fatalities/MW/year, but estimates of fatality rates have come from various wind turbine models, tower heights, environments, fatality search methods, and analytical methods. To improve comparability and asses large-scale impacts, I applied a common set of assumptions and methods to data in fatality monitoring reports to estimate fatality rates of birds and bats at 71 wind projects across North America (52 outside the Altamont Pass Wind Resource Area, APWRA). The data were from wind turbines of 27 sizes (range 0.04-3.00 MW) and 28 tower heights (range 18.5-90 m), and searched at 40 periodic intervals (range 1-90 days) and out to 20 distances from turbines (range 30-126 m). Estimates spanned the years 1982 to 2010, and involved 1-1,345 turbines per unique combination of project, turbine size, tower height, and search methodology.

I adjusted fatality rates for search detection rates averaged from 425 detection trials, and for scavenger removal rates based on 413 removal trials. I also adjusted fatality rates for turbine tower height and maximum search radius, based on logistic functions fit to cumulative counts of carcasses that were detected at 1-m distance intervals from the turbine. For each tower height, I estimated the distance at which cumulative carcass counts reached an asymptote, and for each project I calculated the proportion of fatalities likely not found due to the maximum search radius being short of the model-predicted distance asymptote. I used the same estimator in all cases. I estimated mean fatalities/MW/year among North American wind projects at 12.6 bats (80% CI: 8.1-17.1) and 11.1 birds (80% CI: 9.5-12.7), including 1.6 raptors (80% CI: 1.3-2.0), and excluding the Altamont Pass I estimated fatality rates at 17.2 bats (80% CI: 9.6-24.8) and 10.3 birds (80% CI: 8.6-12.0), including 0.9 raptors (80% CI: 0.5-1.2). Only considering mean fatality rates, and with 36,698 MW of installed capacity as of September 2010 (American Wind Energy Association), wind energy in the United States may be causing annual fatalities of 462,000 to 631,000 bats and 371,000 to 407,000 birds, including 33,000 to 58,700 raptors, depending on whether the Altamont Pass is included. However, potentially large biases and sources of uncertainty remain, field methods vary, and reporting has been inconsistent and increasingly incomplete. Fatality rate estimates should also be interpreted by estimates of utilization rates, but estimates of the latter have also been based on multiple methods and were vulnerable to potentially large biases due to variability in maximum survey distance, proportions of the airspace that were visible to the observer, and degrees of overlap in the surveyed airspace from multiple observation stations.

Proceedings – posters

The abstracts are given in alphabetical order on the presenting author.

PRE-CONSTRUCTION STUDY: RECORDING BATS FROM A HELIUM BALLOON IN COLLISION RELEVANT HEIGHTS WITH AN AUTOMATED SYSTEM (BATCORDER)

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Abstract

When planning and approving wind power plants it is decisive from a species protection point of view if the risk of killing of bats will significantly increase. Prohibitions ban cannot even be avoided implementing CEF measures. Numerous investigations show that bats are active in the height area of the rotor blades and might be killed. But so far only few authors have investigated bat activities in different heights.

The study presented has been carried out over two nights using a helium balloon. Automatically recording “batcorders” registered the bat calls synchronously in three different heights. The results show that bat activities in the height of the rotor blades significantly differ from activities close to the ground or even in the height of tree crowns. The species mapped on the height of the rotor blades (*Pipistrellus pipistrellus*, *P. nathusii*, *P. pygmaeus*, *Vespertilio murinus*) are all hunters in the open air space. These findings correlate with the observances of other authors.

The method using a helium balloon is generally suited for the evaluation of conflicts of a potential location. The synopsis of the state of knowledge of recent studies leads to the conclusion that only investigations in heights relevant for collision allow the evaluation of the killing risk of wind power plants. This assessment is not only important for the protection of species. In the context of necessary switch-offs due to bat protection it also has economic significance.

ENVIRONMENTAL IMPACTS INFORMATION TOOL

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Abstract

The European Wind Energy Association has created an online Environmental Impacts Information Tool (EIIT) to enable the organisation to answer the increasing generic, transnational and more organised concerns about wind energy and its impacts on the environment. The tool aims at providing up - to - date information on potential impacts on biodiversity, both off and onshore. It covers all major impacts which project developers and manufacturers face when designing and developing wind power.

The methodology followed to build the tool consists of identification, selection, abstracts drafting and uploading of the different sources of information. It also comprised a general literature review on the eight main issued identified, i.e. birds, bats, marine life, landscape impacts, light effects, acoustic noise, electromagnetic interference and safety. In addition, it included the identification of key experts on the mentioned topics.

The resulting search-based online tool gives the opportunity to the user to search for information in three different ways:

1. Browsing by category (including: the potential impacts on birds, bats, marine life, landscape impacts, light effects, noise, electromagnetic, safety, geographical scope etc.).
2. Search for documents: Through simple and advanced search options, the user is able to consult the main scientific references on the potential impacts of wind power. He/she can download the available documents and is then directed to the website where the files can be found.
3. Search for experts: Through simple and advanced search options, the user is able to identify the major experts working on wind power environment related issues. He/she can consult the contact details of the identified experts and get in touch with them directly.

As a conclusion, the potential environmental impacts should be approached in balance with the available alternatives, seeking to protect biodiversity through careful planning and mitigation measures.

EFFECTIVENESS OF DETERRENTS TO REDUCE BAT FATALITIES AT WIND ENERGY FACILITIES

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Abstract

Unexpectedly high numbers of bat fatalities have been reported at utility-scale wind energy facilities, especially along forested ridge tops in the eastern United States. These fatalities raise important concerns about cumulative impacts of proposed wind energy development on bat populations and highlight the need for solutions. We implemented a 2-year study to test the effectiveness of an ultrasonic acoustic deterrent for reducing bat fatalities at wind turbines at Locust Ridge I and II Wind Farms located in Columbia and Schuylkill Counties, Pennsylvania. The goal of this study was to redesign previous prototypes of a deterring device to maximize its capability to broadcast ultrasonic acoustic emissions from the nacelle of wind turbines and to test its effectiveness on reducing bat fatalities. Of 64 turbines available, 10 were fit with deterrent devices on the nacelle; three devices were fit to each side of the nacelle and pointed downward into the rotor swept area and two were aimed at a reflector plate to send ultrasonic emissions into the upper part of the rotor swept area (8 devices total for each of the 10 turbines). These turbines were searched each day from early August to mid-October in 2009 and 2010. During this same period, daily searches also were conducted at 15 "control" turbines. We compared average fatality at PGC with treatment turbines using one-way analysis of variance with each turbine as the experimental unit and loge (estimated total fatalities) as the response. Turbines with deterrents had 20-53% fewer bat kills compared to those without deterrents in 2009 and 18-62% fewer bat kills compared to those without deterrents in 2010. Research and development of acoustic deterrents will continue in 2011, and we will discuss future research needs as well as challenges and projected costs of deterrents for future studies at wind facilities.

WHAT DOES BAT ACTIVITY INSIDE THE FOREST TELL US ABOUT THE ACTIVITY ABOVE THE CANOPY? A METHOD FOR CENSURING BAT ACTIVITY AT PROPOSED WIND FARMS IN FORESTS.

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Abstract

Point-stop transects and bat boxes are well known techniques in order to census bat activity and to estimate the possible impact of wind farms on bats. These methods are often applied in open landscapes. But more and more wind farms are proposed within or near forests. What do we census from the ground when the canopy might shade the ultrasound of the bats? In this study our aim was: 1. to investigate how species composition and activity pattern differ between the strata in a forest, 2. to compare these results with the results from commonly applied surveys on the ground (bat boxes and point stop transects).
We used AnaBat systems to monitor the bats in three different strata (5m above the ground, in the canopy and above the canopy) in 2008 in a beech forest in northern Germany. In addition we conducted point-stop transects and used bat boxes in selected nights between April and July 2008.
The results show that the same species were recorded in all strata and by all methods. But the activity patterns and abundances varied strongly between the strata and methods. Particularly species which commonly sustain high fatalities at wind parks (noctule and nathusii´s bat) are highly underestimated when only surveyed from the ground. We conclude that it is impossible to assess the bat activity for a planned wind farm site in the forest by surveying bats from the ground. Instead the bat activity has to be measured above the canopy by installing a long time monitoring system.

IMPACT OF WIND SPEED ON THE ACTIVITY OF BATS

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Abstract

In 2007-2009 we conducted acoustic monitoring of bats in combination with a carcass search at four (seven in 2009) wind turbines at the North Sea coast (ca. 1km from the shore line) resp. in 2009-2010 at five wind turbines northeast of Hannover which is about 200km inland. One of our main aims was to study how bat activity was influenced by wind speed.
For the acoustic monitoring automatic bat detectors (AnaBat) were installed at the wind turbines. The study at the coast was carried out over a three month period from mid July to mid October, in inland between April and November. We recorded at least six bat species at high altitudes. At the coast the most common bat species was nathusii´s bat, followed by pipistrelle bat, serotine bat and noctules wereas in inland the noctules dominate. We found that the two migrating species, nathusii´s bat and noctule, were less sensitive to higher wind speed than pipistrelle and serotine bat. The activity of pipistrelle and serotine bat decreased rapidly above 6-7m/s, whereas noctules and nathusii´s bat hunted often at wind speed up to 8m/s. This wind speed tolerance at the coast is much higher than inland, where the activity already decreases above 6m/s. Still, Nathusii´s bat show a higher wind tolerance there too.

USING CUTTING EDGE TECHNOLOGY TO DELIVER EIA FOR AN OFFSHORE WIND FARM DEMONSTRATOR SITE

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Abstract

Offshore at Blyth, UK, Narec (the National Renewable Energy Centre) have earmarked a demonstrator wind farm site. This gives turbine and foundation manufacturers a test bed for emerging wind farm technologies, in relation to Round 3 development zones. Neatly mirroring this emergent wind farm technology, Natural Power Consultants have sub-contracted APEM Ltd to provide environmental monitoring of the site using state-of-the-art digital aerial survey methods. Using digital High Resolution stills photography, bird (and marine mammal) abundance and distribution can be estimated accurately for the offshore area, contributing robust data to Environmental Impact Assessment. Here we present details of the project, focusing on the approach to ornithological monitoring. The method employs a site-specific sampling regime, based on many independent images, leading to a statistically defensible design; produces images that are processed by analysts post-survey, and are subject to Quality Assurance procedures; produces objective estimates of abundance and distribution that can be modelled and derived in various ways; and leaves a permanent image record for future re-analysis. Additionally, data on bird flight height and direction can de derived from images collected. Example data is provided to indicate the outputs which will ultimately be produced, following completion of the survey set. These data will allow judgment of likely impacts to birds, including tackling questions about protected site impacts and turbine positioning.

HIGH RESOLUTION DIGITAL PHOTOGRAPHY FOR OFFSHORE AERIAL BIRD SURVEYS

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Abstract

Advances in digital and optical technology have been exploited for use in environmental assessment, particularly in relation to offshore wind energy. Traditional aerial survey methods suffered from drawbacks which are overcome by new digital methods, and we here discuss application of these methods to aerial bird surveys in marine areas. Returning to first principles, surveys are designed bespoke for each specific site and question. A series of high resolution digital still images are captured using state-of-the-art camera equipment mounted in a small aircraft. Typically, a grid of images is formed across the survey area, providing a permanent record which can be analysed semi-automatically post hoc and is open to Quality Assurance procedures. This technique has been applied successfully to generate population estimates and describe distribution for several offshore wind farm sites in the UK. Using real digital data, we discuss alternative approaches for survey design and statistical analysis, and investigate the effect on population estimation and precision for different species. Obtaining accurate and precise estimates of bird abundance is crucial to determining and measuring effects of offshore wind farm construction, whilst exact geo-referenced locations of birds can inform decisions on turbine location. New technology can therefore answer essential questions about the impact of offshore development; with further advances in technology, we anticipate digital methods continually improving, both in terms of image quality and realistic survey coverage.

USING A BEFORE–AFTER–GRADIENT DESIGN TO DETERMINE POST CONSTRUCTION EFFECTS OF AN OFFSHORE WIND FARM PRELIMINARY RESULTS

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Abstract

In February 2009, Mainstream was awarded the exclusive right to develop the Neart na Gaoithe offshore wind farm in Scottish territorial waters. With a capacity of 420MW, the project is located in the outer Forth Estuary, some 30km north of Torness, off the east coast of Scotland.
Line transect surveys of seabird and marine mammals using standardised methodologies commenced in November 2009, including data collection for any subsequent monitoring of post-construction impacts.
The use of a Before-After-Control-Impact study design to monitor the impact of offshore wind farms has become standard practise, usually consisting of monitoring the development area and a control area before and after installation. However, due to concerns that such a design has little or no power to detect impacts, plus issues with identifying truly independent comparable control sites in the vicinity of the development site, our study instead concentrated on using a Before-After-Gradient (BAG) design.
Our survey methodology assumes that potential impacts decline with increasing distance from the source. We are surveying all areas within 8 km of the proposed development site. Any potential impacts due to displacement and habitat loss will be detected on the basis of changes in the distribution of seabirds and marine mammals in these waters. We will test for changes in the relationship between distance from the turbines and density between the different phases of the construction process (pre, during, post-construction). In collaboration with the University of St Andrews, we are developing software to perform these analyses using Generalized Additive Models within a Distance Sampling framework.
We will present preliminary results for example species based upon the first years data, assessing the potential power of this methodology to detect post-construction impacts.

IDENTIFYING LIMITS TO WIND FARM-RELATED MORTALITY IN MIGRATORY BIRD POPULATIONS

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Abstract

Lighted offshore constructions cause mortality by collisions especially in nocturnally migrating birds. Plans for large numbers of offshore wind farms in the Baltic and North Sea where millions of birds migrate to and from Scandinavia each spring and autumn has raised concern about cumulative effects on migratory birds at a population level. Current EIA procedures usually consider effects of single wind farms only.

Here we present an application of a method developed to estimate thresholds for additional mortality in marine mammals and seabirds, i.e. long-lived organisms, to estimate mortality limits for populations of migratory birds with strongly different life histories. Using basic data for 43 bird populations (mainly passerines) from Northern Europe migrating across the southern Baltic Sea we show that this method is suitable to set thresholds for collisions with offshore wind farms at a population level.

Results indicate that for the different species studied, an additional annual mortality ranging between < 1-6.9% of the autumn population size could be sustainable. The lowest limits were identified for long-lived species and declining populations. Hence future strategic planning should focus on possible effects on these populations. Species-specific thresholds could be used to guide approval of future wind farm projects and can easily be updated with new information on demographic rates.

ATTESTING BIRD DISPLACEMENT IN PORTUGUESE WINDFARMS

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Abstract

Wind farms can be responsible for negative impacts on bird communities, such as disturbance or displacement. Therefore and given the exponential increase of turbines installed worldwide, a great number of surveys have been conducted. Yet few studies analyzed the data collected through different monitoring programs.
Since 2005, the consultancy company Bio3 has been conducting surveys in several Portuguese wind farms, using standard methodologies. To characterize the bird community according to richness and abundance, survey points were distributed throughout the study areas, which included wind farm and control areas. At each survey point, all birds seen and heard during a 5- minute period were recorded. Simultaneously, it was performed observation points of soaring birds. Birds' movements were mapped and described with as much detail as possible. Both surveys were conducted up to 8 times a year (2 times each season), during pre-construction and first post-construction years.
In order to understand the spatial use of wind farm areas by different bird species and identify potential displacement effects, data collected in different wind energy facilities were analyzed. The data exhibited two particular features, on the one hand observations are spatial correlated and on the other hand, data is characterized by having many zeros. These particularities imply proper spatial statistical analysis capable of accommodating such data structure, like hurdle or zero inflated models and spatial filtering.
With this analysis we seek to identify which species are more vulnerable to the presence of turbines as a result of changes in space use throughout the years. This information can be extremely useful during the site selection process of new wind farms, in the sense that areas with high densities of potential vulnerable species should be avoided. It will also improve future environmental impact assessments and support, in early stages, the development and execution of species-specific mitigation measures.

IMPACTS ON COMMON KESTRELS' (FALCO TINNUNCULUS) POPULATIONS: THE CASE STUDY OF TWO PORTUGUESE WIND FARMS

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Abstract

Since 2005, the Portuguese company Bio3 is conducting a survey of the bird community in two wind farms promoted by Iberwind, Candeeiros and Chão Falcão I e II, both located in central Portugal. After three years of monitoring, the estimates indicated a high mortality of common kestrels (*Falco tinnunculus*) that could be impairing the local populations of this species. To better understand the impact of these two wind farms, we developed a protocol that aimed to accurately estimate the size of these two kestrels' populations, in order to obtain mortality rates. The methodology consisted on the nest searching, transects and observation points to detect the falcons and weekly searches of all wind farms' turbines to detect death birds. In one of the wind farms, the kestrels were also captured and ringed. The preliminary results, obtained between 2008 and 2010, indicated a population size of four breeding pairs in both areas. It was possible to define some territories and identify the more important areas for the species.

In Chão Falcão I e II wind farm, the results seem to indicate a high turnover of the population, which cannot yet be definitely related with the presence of the wind farm because only one bird was found death in the three years of the study. On the other hand, in Candeeiros wind farm, during the last three years, we found 5 carcasses, including adults and juveniles. As the population is not marked, we cannot be certain if these individuals correspond to the identified couples or their offspring. If they do, they were rapidly substituted by others as the number of individuals observed remained relatively stable. The next years will be essential in order to clarify these issues.

IMPACTS ON VEGETATION: A MINOR DETAIL FROM A BIGGER PROBLEM?

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Abstract

It has been verified that wind projects' implementation has essentially two main impacts on flora and vegetation, both triggered by construction and connected to disforestation: i) on the one hand the destruction of important habitats and species, since wind availability is very often found in highly preserved areas, ii) and on the other hand the proliferation of exotic species.

Concerning important habitats and species critical work has to be done in early stages (pre-construction), allowing layout adjustment in order to avoid or minimize impacts. Conversely, wind farm mediated exotic species propagation is almost impossible to avoid, which requires that most of work must be done in post-construction. Concerning important species and habitats, it is easier to avoid impacts in habitats, since most of the times a detailed cartography is easy to obtain. Oppositely, to detect, quantify and georeference important species is often a very challenging work. Several experimental designs aiming to quantify the effect of wind farms' construction on species have been adopted, namely non intensive prospection, prospection in circumscribed areas, random prospection and distance sampling. The choice for one of these methods relies on several criteria which include: i) aims presented by clients, ii) legal stage in which EIA occurs, ii) field topography and iv) budget.

Regarding exotic species propagation, mitigation measures can be adopted during construction although complete avoidance of this impact is unlikely to be achieved. Therefore and acknowledging that humanization of the area will potentiate these species propagation, the implementation of monitoring studies during post-construction is the reasonable solution left, in order to evaluate the need for an eradication plan.

Impacts on vegetation are rarely the main issue, yet it is not that unlikely that the mentioned impacts might have a regional dimension and consequently it should not be considered a minor detail in impact assessment.

MIGRATING BIRDS AND THE EFFECTS OF AN ONSHORE WINDFARM

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Abstract

Although a few studies have focused on the behaviour of migrating birds close to offshore wind power farms, the effect of large-scale onshore wind power farms on the behaviour of migrating birds is little known. The Hörnefors onshore wind power farm, south of Umeå in Northern Sweden, consists of 11 large wind power turbines and is located within a heavily trafficked migratory route. To study the behaviour of migrating birds near the wind power farm, counts of migrating birds have been conducted for two years before establishment of the turbines, during establishment and for one year after establishment (year 2010). The study will continue for at least one more year. During 2010, the study has also included searching for dead birds that have collided with the wind power turbines. These searches have been assisted by bird dogs and have been performed during the most important migration periods in spring and autumn.

Counts of migrating birds have mainly been conducted during spring (April–May) and autumn (August–October), but some counts have also been performed during summer and winter. Most of the counts have been performed during days with large numbers of migrating birds. Between 20,000 and 40,000 migrating birds have been counted yearly. These numbers probably represents 15–30 % of the total number of migrating birds.

The results clearly indicate avoidance of the wind power farm by migrating birds. The number of birds that have collided and been found on the ground is very low. Although avoidance of the wind power farm has decreased slightly from 2009 to 2010, it is still evident that migrating birds avoid the wind power farm.

OFFSHORE WIND FARMS IN THE BELGIAN PART OF THE NORTH SEA: EARLY ENVIRONMENTAL IMPACTS AND SPATIO-TEMPORAL VARIABILITY

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Abstract

To allow for a proper evaluation of the environmental impacts of offshore wind farms in the Belgian part of the North Sea, the environmental permit includes a monitoring program. This program targets physical (i.e. hydro-geomorphology and underwater noise), biological (i.e. hard substratum epifauna, hard substratum fish, soft substratum macrobenthos, soft substratum epibenthos and fish, seabirds and marine mammals), as well as socio-economical (i.e. seascape perception and offshore renewables appreciation) aspects of the marine environment.
Our first two integrated reports focus on (1) monitoring strategy, (2) spatio-temporal variability and (3) early impact assessment.
(1) The monitoring approach consists of a baseline and a targeted monitoring. The baseline monitoring focuses on the a posteriori, resultant impact quantification and deals with observing rather than understanding impacts. The targeted monitoring upgrades the monitoring to a level of process understanding and focuses on a selected set of hypothesized cause-effect relationships of a priori selected impacts. This allows for linking environmental changes to an underlying cause-effect rationale, which is considered a prerequisite for an effective regulatory management.
(2) The marine environment is not stable, but shows a certain natural dynamism at various temporal scales (i.e. from tidal to multi-year cycles). This natural variability should be taken into account when aiming at the quantification or even detection and evaluation of anthropogenic impacts. A proper knowledge of the natural spatio-temporal dynamics is hence considered necessary for a future quantification of the anticipated impacts and for the evaluation of the significance of these impacts.
(3) While most impacts – both positive and negative – will only become established and detectable when more wind turbines will be installed (i.e. local cumulative effects) and or after a certain period of time (i.e. time lag), some localized impacts are expressed from the early stages of the wind farm development onwards. As such, early impacts were detected for (1) the geophysical environment of both gravity based foundation windmills and monopiles, (2) the establishment of hard substratum epifauna and fish as a consequence of the introduction of hard substratum, in an originally soft sediment environment, (3) underwater noise generated during pile driving, and (4) the social attitude towards offshore renewables.

COMBINING MARINE WATERBIRD DISTRIBUTION DATASETS FOR MARINE SPATIAL PLANNING IN WALES

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Abstract

To support strategic planning processes for marine renewable energy, such as the the Welsh Assembly Government's Marine Renewable Energy Strategic Framework and the UK 2nd offshore energy Strategic Environmental Assessment, the Countryside Council for Wales (CCW) are developing a series of GIS-based evidence layers to enable spatial identification of environmental receptors considered potentially sensitive to the deployment of renewable energy devices. One key receptor group are marine waterbirds for which the Welsh coast holds many important breeding, passage and wintering sites. WWT Consulting is working with CCW to identify, combine and analyse spatial marine datasets from boat and aerial surveys to derive sensitivity maps of marine waterbirds around the Welsh coast.

Boat-based and aerial survey data were analysed to determine strip widths for species from each platform and suitable methods for combining sat and flying birds. Bird densities corrected for detection distances and coverage were applied to a mapping grid for each species or species group for each platform. Maps showing the highest densities of birds recorded were produced by selecting grid cells from the dataset containing the highest density of birds, corrected for coverage. Sensitivity indices were derived using a matrix of published and consensually agreed scores relating to species life history, behaviour, status and location.

Sufficient data from both boat and aerial datasets existed for Gannet, Fulmar, Manx Shearwater, Guillemot and 'auk species' to produce combined dataset density maps. Maps for other species were produced using one or other dataset. Population and conservation status factors were compiled for 31 marine waterbird species to be used in marine spatial planning modelling.

The method presented here provided a rapid solution to displaying coverage-corrected distributional data from boat and aerial surveys that could be used for sensitivity mapping. A fuller analysis of these datasets for UK waters is currently underway.

THE "WOLF FUND" – A NON CONVENTIONAL COMPENSATION SCHEME IN PRACTICE IN PORTUGAL

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Abstract

The Iberian wolf in Portugal is classified as a priority species under the European Union Habitats Directive and protected by a specific national law. The development of renewable energy is established as a national priority. In the last decade, in Portugal, wind energy has strongly increased with the instalment of more than 3500 MW. There is a significantly overlapping between areas with high wind potential and the wolf's range, resulting in several access roads and wind farms on these areas. Although there were adopted minimization measures, they were considered insufficient and the Portuguese government has determined the implementation of a compensatory scheme. The scheme basis is a fund with the purpose of financing wolf habitat management actions during the wind farms lifetime. The "Wolf Fund" is financed by wind energy projects accordingly to their installed capacity. To manage this fund, a group of 3 wind energy projects joined efforts and created an association in 2006. There are now 14 wind energy projects associated on the north and central of Portugal, with an installed capacity of 473 MW contributing to the "Wolf Fund".
The compensatory scheme has 5 types of actions in development: forest management; reduction of wolf damages on livestock; reintroduction of wild prey; creation of non-hunting areas; and, management of land plot for conservation. Since 2007 several actions were implemented including: 20 ha of forest management (forestations and forestry); an autochthonous tree nursery; incentives to traditional herding; roe deer breeding facilities (reproduction and quarantine centres for wild prey reintroduction); creation of 1600 ha of non-hunting area.
The "Wolf Fund" allows a constant and effective response to the results of the wolf population monitoring plans in course. Although the assessment of the conservation results is still impaired, this scheme is considered promising and a breakthrough on compensatory measures in Portugal.

THE ASSESSMENT OF MORTALITY AT AN ONSHORE WINDFARM CORRECTED FOR SCAVENGING RATE AND DETECTION RATE

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Abstract

The Food and Environment Research Agency (Fera) carried out collision monitoring at a wind farm in Kent, UK in 2009 as part of the post construction ornithological monitoring schedule. The monitoring comprised carcass searches around turbine bases and in control areas and additional field staff detection rates and scavenger removal trials. Carcass searches are the most direct way of estimating the number of collisions, and therefore determining the likely impacts of turbines on species of conservation importance. The main site (wind farm area) comprised of 26 turbines, 26 survey squares around the turbines and remaining area within wind farm envelope. Carcass searches were undertaken twice per month for the wind farm area and control sites during the winter and passage periods .No previous trials using this exact methodology have been undertaken in Europe (with control sites and observer detection rate estimation), though similar studies have been done in USA. An adjusted mortality rate was calculated for each turbine, and the overall rate for the entire array was found to be 6.01 fatalities per turbine per year, which compares with similar figures found elsewhere.

THE PREDICTION OF FLOCK SIZE FOR MIGRATING PINK-FOOTED GEESE FROM RECORDED RADAR DATA

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Abstract

As part of an EIA monitoring programme of pink-footed goose (*Anser brachyrhynchus*) migration by bird detection radar through two wind farm on the east coast of the UK by Fera and its predecessor organisation CSL, an attempt was undertaken to predict flock size from radar parameters that are typically recorded to the database in avian laboratory type bird radar systems. The presence of a large amount of flock size data confirmed by visual observation collected during the EIA monitoring facilitated the possibility of this analysis. The use of database records rather than information available in raw radar images was initially selected so that flock size predictions could be made without the need for complex image analysis or neural network software. A positive relationship was found between flock size and mean area (pixels) of targets meaning that it is possible to provide more accurate flock size estimations for flocks not seen by observers, for example those flying at night, and when tested on additional flocks of known size, this method was able to predict flock size to within 30 birds. (See paper by Simms et al submitted to this conference for methods of identifying goose flocks from radar data). The provision of accurate flock sizes is particularly important in estimating collision risk of birds encountering wind farm arrays where otherwise an average flock size must be used for all flocks of unknown size resulting in an over or underestimation of the risk. A further study is planned in conjunction with the University of York to use recorded raw radar to predict flock size and other parameters with a greater degree of accuracy and autonomy, removing the need for detailed manual inspection of the data.

THE APPLICATION OF INFRA-RED THERMAL IMAGING TO MEASURE NOCTURNAL BIRD ACTIVITY

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Abstract

There are survey protocols and impact assessment techniques for birds present and active during the day in and around potential wind farm sites. There are birds active at night for which survey and assessment techniques are still under development. RPS has been investigating the use of infra-red thermal imaging (TI) to provide information on such nocturnally active birds as part of its work on wind farm impact assessment.
To develop the use of TI for the investigation of nocturnal bird activity at potential wind farm sites, identifying its strengths and weaknesses. Methodology: A TI camera has been used for direct observations and image recording with recorded images analysed manually and with image analysis software. Studies have been undertaken in marine, wetland and terrestrial environments and targeted at seabirds, waders, wildfowl and nightjar.
Methods have been developed to detect and quantify the nocturnal activity of seabirds, waders, wildfowl and nightjar. They have been applied in wind farm impact assessments that have been considered by regulatory bodies in the UK.
TI is not a universal panacea to the need to detect and measure nocturnal activity of birds. It should be applied where it is superior to, or able to complement, other techniques such as image intensifiers and radar.
In the absence of information on the nocturnal activity of birds there is a risk that a wind farm might be consented that places a bird population at risk of displacement from specific areas or collision with the turbines. In the absence of information taking a precautionary approach risks refusing a wind farm that does not have significant impacts. The development of methods for assessing nocturnal bird activity allows decisions to be made in the knowledge that the risk and scale of impact on nocturnally active birds have been quantified.

IDENTIFYING OPTIONS TO PREVENT OR REDUCE AVIAN COLLISIONS WITH OFFSHORE WINDFARMS

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Abstract

Offshore wind farms may potentially affect bird populations through the displacement of birds due to the disturbance associated with developments, the barrier they present for migrating birds and birds commuting between breeding and feeding areas, habitat change/loss and collision mortality. The principal available options for mitigating these negative effects aim to reduce the risk of collisions and include the mandatory shut down of some or all wind turbines within a wind farm during certain periods (e.g. migration or breeding seasons). Other existing mitigation options include alternative placement of the wind farm and habitat enhancement elsewhere. This project had four main objectives:
i. To review current options for mitigating against avian collisions with offshore wind farms, both in the UK and elsewhere;
ii. To identify existing and novel mitigation methods that could be used to minimise avian collisions;
iii. To identify which bird species are considered most at risk to collisions with offshore wind farms in UK waters;
iv. Using a case study, to model different scenarios, e.g. increasing avoidance rates, against which the potential of different mitigation options might be evaluated.
The work identified 10 mitigation measures that were then evaluated according to their technical feasibility, implementation and operational costs, and potential effectiveness in reducing collisions. These included: temporary shut-down and associated use of remote population monitoring; options to reduce motion smear; options to increase visibility; structural modifications and minimising use of lighting.

IDENTIFYING SPATIAL CONFLICTS BETWEEN SEABIRDS AND OFFSHORE WIND FARMS IN NORWEGIAN WATERS

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Abstract

With the growing need for renewable energy the wind energy sector has experienced a rapid growth worldwide over the last decades. In Norway increased focus is now being put on the possibilities for utilizing the energy obtained from wind. In connection with the new Norwegian "offshore energy act", the need for a strategic environmental impact assessment for the establishment of offshore wind power plants was addressed.

The objective of this study was to perform an initial, large scale, screening to identify possible spatial conflicts between seabirds and offshore wind power plants in Norwegian waters. We used the methods developed by Garte & Hüppop (2004), with some modifications, to evaluate seabird vulnerability to wind power plants. Based on ten factors derived from species' attributes, focusing on risk of collision with turbines, vulnerability to disturbance and conservation status, a species-specific vulnerability index (SSI) was calculated. Combined with a relative proportion of species present in 10 x 10 km squares within the study area a wind farm sensitivity index (WSI) was created.

The results of the study showed a clear difference in the amplitude of the WSI between areas and seasons. In the breeding season it was primarily the largest seabird colonies that displayed the highest WSI-values. In the winter season the areas with high WSI-values were typically important for a range of species probably due to good feeding conditions. Although giving a good overall identification of areas of potential high vulnerability to establishment of offshore wind power plants, this method had some limitations. We conclude that using this index can clearly be a useful tool for comparing large-scale vulnerability of seabirds towards offshore wind farms. However, it cannot substitute a detailed EIA when single areas are being targeted.

GEOREFERENCED DIGITAL PHOTOGRAPHY ALLOWS AN OBJECTIVE QUANTIFICATION OF STAGING SEABIRDS NEAR OFFSHORE WIND FARMS

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Abstract

An expansion of off-shore wind energy production could lead to a significant loss of wintering and staging habitats for seabirds. To assess the impact of wind farms before, during and after their construction, the standard investigation concept of Germany's Federal Maritime and Hydrographic Agency (BSH) currently recommends ship- and aircraft-based bird surveys. These observation-based aerial surveys, however, have methodological disadvantages: Low flight elevation (76 m) necessary for species recognition and high flight speed in combination with large numbers of birds allow only rough population estimates. In addition, aircrafts flying at this elevation significantly disturb resting birds and further obstruct their precise quantification. In this study, we compared estimated seabird numbers collected during an aerial survey with numbers derived from digital aerial photographs. The photographic survey was carried out at a height of 200 m above sea level, using a high-resolution digital camera (39 Mpx). 415 orthographic photos corrected for geometry and scale were taken at regular intervals along defined transects. The difference between visual and photographic methods varied considerably among species: 85% (common eider, *Somateria* mollissima), 41% (long-tailed duck, *Clangula hyemalis*) and only 2% (common scoter, *Melanitta nigra*) of the photographically documented individuals were observed. Thus, observational surveys significantly underestimated the actual number of seabirds at sea. The reasons for this methodological discrepancy are discussed.

BIODIVERSITY TRACKING SYSTEM V2.0: AN AUTOMATED WEB TOOL FOR BIODIVERSITY SURVEYING

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Abstract

Nowadays, tracking biodiversity using the satellite telemetry technique is commonly used to survey several species and understand the interaction of individuals with infrastructures, such as wind farms. Projects that involve this sort of techniques, using Argos system, also require resources specially assigned to perform manual and repetitive tasks during a long period of time. The final goal of such tasks is to decrypt and organize data produced by Argos.
In order to overcome such time consuming tasks, Biodiversity Tracking System (BTS) was created, facilitating data reception, processing and report. BTS was developed using applications like: PostgreSQL (Data Base Management System DBMS), Manifold Internet Map Server (geographical data Web server) and Openlayers (web client to handle geographical data). Registered users can access their information through a WebGIS application, where they can use filters to perform geospatial analysis.
The most recent version of BTS (2.0) has new query features and allows users to access their data using other GIS applications that support the Web Map Server WMS protocol. Modelling features are currently being developed in order to empower this application with tools that can predict short term individuals' movements.
BTS 2.0 allows its users to save time and gives them a set of tools and features which improve substantially species survey using satellite/GPS/GSM telemetry. A demo will be available at the conference for participants to test it.

WIND FARM IMPACTS ON WOLF POPULATIONS - THE PORTUGUESE EXPERIENCE AND FUTURE PERSPECTIVES

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Abstract

The wolf (*Canis lupus*) is classified as an endangered species in Portugal since there are less than 250 mature individuals in nature. During the 20th century its populations suffered an 80% reduction in their distribution range due to human persecution, lost and fragmentation of habitat and general decrease of natural preys. The wolf last refuges became the remote mountain areas of North and Central Portugal. With the government encouragement for clean energy, several wind farms were constructed during the present decade in the actual wolf range. The first monitoring plans were based on monthly or seasonally scats surveys over a large study area (more than 100km2), divided in big sample units (UTM 5x5km squares) centred on the wind farm. It was analyzed changes on the use of space at each unit and on the breeding sites between years. Such a coarse grid was unsuitable to verify subtle differences in wolf space use and direct impacts of the infrastructures, so a UTM 2x2km grid was implemented afterwards. With the increasing availability (technological and economic) of new methods such as GPS/GSM telemetry, camera trapping and genetic analysis, plain scat surveys became outdated since some genetic results demonstrated the presence of a significant number of dog scats among wolf samples. Nowadays, Portuguese researchers and government agents are seeking for a methodological optimization where data collection and analysis is reliable, replicable and economically sustainable. Is our understanding that wolf monitoring plans should be regional (several packs) rather than local (one infrastructure), using the methodology that best suits the programs objectives: telemetry for individual level analysis, scat surveys with genetic validation for population level analysis and camera trapping for community level (wolves and their wild preys) evaluation.

GROUP NAVIGATION AND WIND FARM COLLISION AVOIDANCE IN FLOCKS

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Abstract

The UK has committed to a substantial shift towards renewable energy in order to comply with EU targets of sourcing 20% of energy from renewable sources by 2020. This has driven dramatic growth in proposed wind farms which are set to treble the existing number. The impact on wildlife of an increased density of wind farms is unknown. Studies have shown that birds can be affected in several different ways including loss of habitat, displacement due to disturbance, and collisions. Of these, collision is potentially the most difficult to prevent, and accurate predictions of the number of impacts is required.

Currently, probabilistic models such as Band *et al*. (2000) are used to determine the expected number of bird strikes. However, collision avoidance is only included as a simple multiplier based on predictions from field data which can be difficult to attain.

We will present an individual based model which improves on previous methodology by incorporating aspects of collective motion of birds to simulate and quantify likely avoidance behaviour. In modern computational models of collective motion individuals move according to a hierarchy of rules (Couzin *et al*., 2002) with group motion adhering to a “many wrongs” principle, in which navigation is achieved through local interactions with nearest neighbours (Codling *et al*., 2007; Bode *et al*., 2010) This approach allows the impact of group interactions on collisions to be assessed in the context of various ecological and engineering scenarios. The results of this preliminary model will inform subsequent field observations at known collision sites where stereoscopic vision techniques will be employed to identify key parameters in 3-D tracking reconstructions of migrating goose flocks.

BREEDING SUCCESS IN WHITE-TAILED EAGLES IN SMØLA WINDFARM

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Abstract

Despite producing electricity without emission of greenhouse gases, wind power plants are not free from environmental impacts. They demand substantial areas and have proven to have impacts on birds in general, and raptors in particular. Increased mortality from collisions with turbines, disturbance leading to displacement and loss of or reduced habitat quality are presented as the main impacts on birds. Most effort has been put into documentation of collision and collision risk assessments, while few studies have investigated the effect on breeding birds.

We investigated the effect on breeding success in white-tailed eagle at an on-shore wind farm in coastal Norway, where eagles bred in good numbers before a wind power plant was built. In more detail we investigated whether the local breeding success changed over time when comparing pre-construction data with post-construction data controlling for the distance from the turbines. Twelve years of data from altogether 52 white-tailed eagle territories were analyzed using a generalized linear mixed model. We found a significant effect of the interaction between time period and distance to turbines, showing that the territories within, or close to, the wind farm in the time period after development experienced significantly lower breeding success than the same territories before development. This effect was caused by increased adult mortality from collisions, increased disturbance and loss of habitat. Results from this study emphasize the importance of choosing the right locations for wind power plants.

IMPLEMENTATION OF AVIAN RADAR-SCADA INTERFACE TO MITIGATE AVIAN MORTALITY AT WINDFARMS

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Abstract

A wide array of wildlife impacts has been documented at wind farms worldwide, and an important subset is collision fatalities of long-lived raptors and vultures. Challenges for mitigating collision risk of these types of birds include accurately identifying when they are at risk, minimizing turbine downtime to allow for profitable energy production, positioning radars for effective coverage of targets near turbines, and finding a solution that is applicable to the myriad of collision causes.

An innovative way to mitigate avian collision risk while meeting these challenges is to use a radar-based mitigation system that integrates radar, capable of detecting when birds are at risk in real-time, with the wind farm Supervisory Control and Data Acquisition (SCADA) system, which can implement mitigation measures ranging from issuing alerts to wind farm operators to idling turbines. This technology has been successfully implemented at several wind farms since 2009 for migratory songbirds, however different mitigation rule sets are needed to address high-risk collision conditions of raptors, vultures and other soaring birds.

The soaring bird application uses radar-assigned risk indices for individual targets relative to their distance and heading from each wind turbine as measured by the avian radar system. These indices can then be used to define high-risk strike times. An example of the soaring bird application at TORSA's El Pino Wind Park in Spain for griffon vultures (*Gyps fulvus*) will be presented. Site specific parameters associated with high-risk collision conditions of griffon vultures will be incorporated into the soaring bird rule set, and adaptive management will continue to evaluate and refine the curtailment criteria over time. This mitigation technique minimizes both collision risk and turbine downtime and provides an important tool in the comprehensive mitigation process for wind farms.

NEAR-REAL TIME TRACKING OF GOLDEN EAGLES IN NORTHERN SWEDEN – GPS DATA CAPTURE, GSM DATA TRANSMISSION AND GIS VISUALIZATION

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Abstract

Abstract: GPS tracking of wildlife has become an important tool for ecological monitoring and research projects. Weight and data transmission limitations, as well as manual data handling made it difficult in the past to track birds in near real-time. As part of several proposed wind energy production projects in northern Sweden 13 golden eagles (GEs), 5 juveniles and 8 adults, were captured and equipped with one of 2 types of solar-powered GPS units during summer and fall 2010. While one unit type used the ARGOS satellite system to transmit positions taken every hour, a novel type used the ground based GSM cell phone network to transmit positions taken every 10 minutes. The transmitted data were automatically received, validated and inserted into a centralized database. A web map interface was used to visualize the positions in near-real time in a web browser. The system is implemented as part of the 'Wireless Remote Animal Monitoring' (WRAM) system in Sweden. Between July and November 2010 we received 12 380 valid positions. The shortest time interval between fix and delivery of positions was only 2.5 minutes for GSM compared to 75.1 minutes for ARGOS units. The fast delivery in near real-time and the high spatio-temporal resolution of the data enabled researchers and fieldworkers to remotely monitor previously unknown use of home ranges in potential wind farm and control areas, and also survival status of the birds. In addition, after field controls of spatio-temporally clustered GE positions, it was possible to locate frequently used perching and feeding sites to establish additional trapping sites.

PREDICTING THE NUMBER OF BIRD COLLISIONS: METHODS AVAILABLE AND THEIR LIMITATIONS

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Abstract

Collision victims among birds are considered one of the major ecological drawbacks of wind energy. When planning wind farms, onshore or offshore, it is often legally required to assess the species-specific number of bird collisions. We made different types of assessments of collision risks of wind farms over the last 15 years. Especially Environmental Impact Assessments and Appropriate Assessments (cf. Bird and Habitat Directives) were fed with results from calculations using models or relatively simple equations. Based on our experience and data from research on collisions, we have developed methods to predict species and numbers of collision victims both onshore and offshore. We distinguish three possible methods:
1. starting from data on numbers of birds found at comparable sites,
2. starting from collision chances or rates at other sites (Bureau Waardenburg – model?) and
3. using the 'Band model'.
Option 1 is basically fed with data from searches for dead birds in wind farms, option 2 with data from species-specific collision rates when passing wind turbines or wind farms. All three include data on wind turbine size and spacing, although in different ways. In the presentation, we will work out the three options, discuss strong and weak sides and when to use them. We will show how they have been used and improved in recent years, both for small sites on land and for new offshore wind farm plans in the Netherlands.

THE INTEGRATION OF NATURE PROTECTION INTO ENVIRONMENTAL WIND FARM ASSESSMENT PROCEDURES IN CROATIA

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Abstract

Despite the fact that Croatia has significant natural resources of wind energy, especially in mountainous regions, current wind energy production has a negligible proportion in overall national renewable energy production. There are only four operational wind farms with nearly 70MW of total output, but many more are in different stages of development process.
The beginning of wind farm development in Croatia in 2000 coincided with the establishment of modern nature protection legislation. The accession of Croatia to international agreements and the European Union gave a strong incentive to renewable energy development, but simultaneously led to stricter nature protection requirements. Therefore, development of nature protection standards can be analyzed by reviewing the wind farm impact assessment procedures conducted in the past 10 years.
Wind farms are usually sited on isolated exposed areas to ensure high average wind speeds and to maximize energy capture. Often, such locations comprise sensitive or endangered species and habitats, so there is a need to avoid or, if not possible, minimize or mitigate negative effects. According to the current legislative framework, the Environmental Impact Assessment (EIA) is obligatory for wind farms with total output greater than 20 MW. For smaller scale projects (range of 10 to 20 MW) evaluation of the need for assessment is mandatory. The impact on biodiversity and landscape is being assessed in the scope of EIA.
The Ecological Network of the Republic of Croatia was proclaimed in 2007 on 47% of land territory. If a planed wind farm could have a significant impact on the conservation objectives of a certain ecological network area, the Appropriate Assessment is mandatory.
This paper analyses wind farm development in Croatia in terms of the site selection criteria, nature protection requirements and measures proscribed with the aim of minimizing the negative impact on biodiversity, especially birds and bats.

IMPACT ON BIRDS FROM COLLISIONS WITH WIND TURBINES IN FLANDERS (BELGIUM)

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Abstract

The government of Flanders (northern part of Belgium) wants to increase its wind energy capacity, and stimulates research into possible negative effects on fauna. The impact from bird collisions was studied at 7 land-based wind farms in Flanders. The study objective was to get a better understanding of the current impact, and to use the results for advice and impact assessment at planned wind farm locations. Weekly or twice weekly searches for collision fatalities were performed under the wind turbines. The collision fatality numbers (with correction factors for available search area, search efficiency and scavenging) varied from 0 to 125 birds per individual turbine per year. The mean number for the 7 wind farms (with correction) varied substantially with 1, 3, 7, 12, 21, 26 and 42 birds per turbine per year. Most of the fatalities were local and common birds like gulls, but also endangered species were found. The large number of collided gulls and terns in two wind farms was striking, all the more because these birds are largely diurnally active. These collisions were the result of local migration of gulls towards a sleeping place, and foraging flights of gulls and terns near their breeding colony. A significant negative impact on the breeding tern colony was calculated. It was also found that the number of gull and tern fatalities depends largely on the number of birds crossing the wind farms at rotor height. The size of the turbines seems to be a less important factor, although there is a tendency (not significant) towards slightly more fatalities with larger turbines (numbers per turbine for the same area). The calculated collision chances for gulls with small and large turbines confirm this trend. Obviously, factors like species, flight height and properties of the wind farm, will also be very important.

SITE SELECTION FOR NEW WIND FARMS IN FLANDERS (BELGIUM): NEW DYNAMIC DECISION-INSTRUMENT FOR BIRDS AND BATS

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Abstract

The government of Flanders (northern part of Belgium) wants to increase its wind energy capacity. However, wind energy is not without its own potentially damaging consequences for nature conservation. Birds and bats can collide with wind turbines, or encounter the vortex wake behind the turbines. They can also become disturbed in their breeding, resting, and foraging areas, or during local and seasonal migration. There is a need to prevent any adverse environmental effects. In general, it is recommended not to build wind farms close to important areas and migration routes of birds and bats. Although the possible impact for planned wind farms can be estimated, in a significant number of cases, there can be a substantial lack of data to make a reliable assessment of the potential impact. In application of the precautionary principle and for minimising cumulative effects, site selection at a strategic level should be the first stage in the search for new wind farm locations. Therefore, a dynamic decision-instrument concerning birds-bats and wind farm planning was designed for Flanders. This instrument includes a GIS based vulnerability map for birds, which is made up from several component maps with important bird areas and migration routes. These component maps were created from available bird distribution data, sensitivity categories and policy frameworks. The vulnerability map shows a gradation of the potential risk for significant impacts on bird populations when wind farms should be constructed. It can be used at strategic level (local and regional spatial planning) for mapping possible wind farm locations, areas where more study will be needed, and provisional 'no-go areas'. Although the vulnerability map has its limitations (detailed information is not available for all areas), it can also be used as starting point for environmental impact analysis at a project level.

ACOUSTIC MONITORING OF BIRDS: RECENT ADVANCES AND APPLICATIONS FOR WIND ENERGY

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Abstract

Renewable energy is a key to mitigating climate change and its effects on biodiversity, and wind energy projects have proliferated worldwide as examples of one of its most sustainable forms. However, the growth of wind energy projects has led to increased concern about wind projects' effects on biodiversity, namely two primary short-term impacts: 1) direct, resulting from collisions of flying organisms, particularly birds and bats, with turbine blades; and 2) indirect, resulting from the footprint of the turbines and associated infrastructure like roads and transmission lines. Nocturnally migrating birds and night-flying bats exemplify the former impact.

Hemispheric-scale bird migration involves billions of individuals annually, and frequently these movements occur under the cover of darkness. Direct study, therefore, is often impossible, moreover, some nocturnal migrants may be difficult to detect in breeding and non-breeding habitats, posing an even greater challenge to monitoring and conservation of populations. Furthermore, these massive movements often depend on weather patterns, particularly prevailing winds. Consequently, migration pathways often overlap significantly with areas of highly sought wind resources, thus exposing bird populations to potentially serious risks from proliferating wind-power development. Minimizing impacts to birds will depend on our abilities to predict migration in space and time and to understand bird behaviour around turbines.

Whereas advances in technologies such as radar and thermal imaging can quantify aspects of bird migration, only the recording and identification of distinctive vocalizations made by birds in flight can provide species-specific data on birds migrating at a specific place and time which would be important for species of special concern. Therefore, we propose that a multimodal sensor system that includes sophisticated acoustic recording and analysis components is critical to develop a complete understanding of nocturnal migration and to monitor hard-to-detect species, particularly in wind resource areas and at wind energy sites.

The Cornell Lab of Ornithology is creating a powerful system for analyzing audio recordings of flight calls of nocturnally migrating birds, by applying technology that minimizes time-consuming human review through advanced sound analysis software to manage, detect, and classify bird sounds. Here we present sample data, descriptions and depictions of software and hardware, and references related to our unique bioacoustic databases and monitoring protocols. Our long-term goals for this initiative include: (1) developing and implementing an automated system for recording and analyzing large amounts of avian acoustic data; (2) applying this system to unravel the mysteries of nocturnal bird migration at continental and hemispheric scales; and (3) using acoustic data to develop risk assessment and forecast models to assist the wind-power industry to site and operate rapidly expanding facilities while minimizing impacts to migratory birds (and bats). The Lab is also partnering with government, private sector, environmental, and academic groups to assist in the synthesis of these acoustic data with additional biodiversity, anthropological, industrial, and meteorological data to guide the siting of wind energy projects.

ESTIMATING THE NUMBER OF BIRD COLLISONS AT OPERATING WIND POWER TURBINES IN NORTHERN GERMANY

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Abstract

The determination of true collision rates in operating wind power plants is rarely subject of field studies. Most investigations are dealing with EIA issues in the planning process of wind farms. In autumn 2004 BioConsult SH adopted and modified the method of systematic line transect search for collision victims and carried out experiments dealing with searcher and availability bias in the conditions in northern Germany. In autumn 2009 BioConsult SH performed a multi-method approach to determine the impact of existing wind turbines on bird and bat migration on the island of Fehmarn, Germany (see presentation of Reichenbach & Grünkorn, this conference).

In exposure experiments the re-sighting rate carcasses differed significantly for vegetation cover, carcass size and the distance from transect line, but not between persons (estimator of searcher bias/ search efficiency). In weekly controls, exposed dead birds remained four days on average (estimator of availability bias/ carcass removal).

As we often found only parts of dead birds or the remaining of scavengers, the cause of death was pragmatically judged by the distance to the wind turbine. We defined all carcasses within the radius of the total turbine height as collision victims. In total, after approximately 700 km of line transect effort in autumn 2009 we found 61 collision victims in four wind farms. 19 bird species were recorded. Important taxa were gulls (44%), passerines (28%), raptors (10%) and waders (5 %). It is remarkable that we did not find any bird species associated with the broad fronted nocturnal mass migration (e.g. thrushes). The species composition reveals staging birds with frequent flights back and forth in their feeding habitat as most frequent victims.

Considering the actual number of collision victims and the correction factors derived from experiments, the number of collisions was 13 per wind turbine and year. This estimation corresponds with our findings in northern Germany (2004) and published data in the Netherlands but is considerably higher than in several studies in North America. Field studies of collision rates can evaluate the power of collision risk models.

HOME RANGE OF RAPTORS (RED KITE, MONTAGUE'S HARRIER AND WHITE-TAILED EAGLE) IN THE VICINITY OF WIND POWER PLANTS IN GERMANY REVEALED BY TELEMETRY STUDIES

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Abstract

Germany like other countries has ambitious plans to increase the proportion of national energy production generated from wind power in the coming years. Birds of prey predominate among collision victims. In order to understand the reasons underlying this phenomenon, the Michael-Otto-Institute within NABU, the consultancy BioConsult SH and the Leibniz Institute for Zoo and Wildlife Research recently terminated a research project on birds of prey and wind farms. The German Ministry of the Environment, Nature Conservation and Nuclear Safety financed the project in full.

The occurrence of birds of prey next to potential sites for wind farms has often led to court cases about refusals of permissions to erect wind farms. In particular white-tailed eagles (*Haliaetus albicilla*) and red kites (*Milvus milvus*) and Montagu's harriers (*Circus pygargus*) have been involved. In order to shed more light on the reasons for the collisions, a research project has been scheduled: Birds of prey and wind farms: analysis of problems and possible solutions. The main aim of the project was to understand when, where and why birds of prey are at risk of collision with wind turbines. Better knowledge of the underlying factors causing collisions will hopefully help to solve the conflict between the occurrence of birds of prey and wind farms in the future. A further aim of the project is to develop measures to minimize collision frequencies. Practical guidance for wind farm developers and local and federal authorities have been developed.

For all focal species, individuals were equipped with VHF- or GPS-transmitters in order to study their home ranges and risky situations in relation to the position of wind farms.

BATS AND WIND FARMS IN FINLAND - THE VERY FIRST STEPS

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Abstract

In Finland, like in many other countries in the world, new wind farms are being planned in large numbers. In many cases the authorities ask for an EIA, some of these include for bats. BatHouse has been conducting some of these bat studies. The aim of the bat studies has been to determine if bats and especially bat migration occur in the wind farm area so that the impacts on bats (i.e. mortality) can be estimated and, if necessary, mitigation acts can be recommended.

The first bat study, done as a part of a wind farm project, was conducted in 2009. In 2009-2010 BatHouse has been involved in ten different wind farm projects in Finland. So far all projects have only consisted of pre construction surveys, windmills have not yet been built on any of the study sites. Systematical searches for dead bats caused by other existing windmills have not been done, even though dead bats occasionally have been found.

Migrating bats were studied with AnaBat detectors placed in weather proof boxes equipped with an external battery. The AnaBat detectors have been out in the field from April/May till October/November, which is the active period for bats in Finland.

So far the results have shown that migrating bats species occur in all of the study sites along the coasts. The most common migrating bat species is nathusius bat (*Pipistrellus nathusii*). Migrating routes for bats has clearly been seen in many places. Furthermore, these long term AnaBat studies have given new information about the distribution of several of the bat species in Finland.

Based on the results, continued surveys have been recommended in high risk areas to be able to recommend specified mitigation actions. More studies are needed to understand the migration pattern of bats in Finland.

DISTRIBUTION OF WADERS AND SMALL PASSERINES IN RELATION TO WIND TURBINE PLACEMENT AT THE SMØLA WIND-POWER PLANT, NORWAY

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Abstract

The locations of waders and small passerines within and in the vicinity of the Smøla wind-power plant were surveyed using standard line transect methods in three transect blocks, A (west edge of turbine arrays) B (within arrays), and C (east edge of turbine arrays). Bootstrapping procedures were used to adjust for reduction in detectability of birds with distance from the transect line. The distance of each location to the nearest wind turbine location was calculated and compared with random locations generated for each species and transect.
29 species were recorded; most were too uncommon for further analysis. It was possible to analyse bird position with regard to turbine proximity for 5 species: two waders, dunlin C*aldris alpina* and golden plover *Pluvialis apricaria*; and three passerines, wheatear *Oenathe oenathe*; meadow pipit *Anthus pratensis*; and skylark *Alauda agrestis*.
O. oenathe was found highly significantly further away from turbines than would be expected on a random distribution in all three transect fields. *A*. pratensis was, conversely, found closer than expected to turbines in areas A and B; but further away than expected in area C. A. agrestis showed no significant deviation from a random distribution. For waders, *P. apricaria* was found significantly further than expected from turbines in areas B and C; and dunlin *C. alpina* further than expected in area B; but closer than expected in area C.
A. pratensis, *O. oenathe*, and *P. apricaria* meadow all prefer rockier areas with out-crops as habitat. They would be expected to be more common close to turbines in areas A and B (mosaics of bog and rocky outcrops), since turbines are most often placed on rocky bases; and further away in area C, as the habitat there is more suitable at distances further from the turbine. This pattern is observed for *A. pratensis*, but the opposite pattern is observed for the wheatear *O. oenathe*, and *P. apricaria* in Area B. This suggests they are disproportionately avoiding the vicinity of turbines. For *C. alpina* data is consistent with the distribution of preferred boggy habitat as the main factor affecting the results.
The species found at Smøla are all common and widespread; however, if this behaviour is representative of rarer small birds and waders it may be significant for their populations if wind-power plants are built on or close to concentrations of such species, either in the breeding season or at other times.

ASSESSING AVIAN-WIND TURBINE COLLISION RISK: AN NEW APPROACH ANGLE DEPENDENT MODEL

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Abstract

Due to the potential impact on endangered and protected bird species, it is becoming common to use model simulation to assess the risk of collision of local and migratory bird populations resulting from wind resource developments prior to their construction. We describe a mathematical model which estimates the probability of a collision between a bird passing through a wind turbine and one of the turbine components. The Hamer Risk of Collision Model includes significant additions and improvements from previous models completed by Band *et al.* (2007) and Tucker (1996) by accounting for different angles of avian approach other than perpendicular or parallel to the turbine rotor plane, and by taking into account the statistical distributions of wind and flight characteristics at the wind resource area using Monte Carlo sampling. We calculated a comparison of average collision probabilities across a single GE 1.5se wind turbine for different raptor flight path approach angles relative to downwind using the mean recorded ground velocity of these birds measured in the field. We demonstrate, using a case study of fall raptor migration data, that accounting for the angle of approach has a significant effect on the estimated collision probability with resulting mortality estimates as much as 31% higher. Furthermore, our state of the art model accounts for: 1) three-dimensional blade characteristics and number of blades; 2) different turbine avian avoidance rates and wind park displacement rates; 3) monopole dimensions, hub/turbine height, and nacelle dimensions; 4) rotor speed and rotor pitch as a function of wind speed; 5) precise point of entry into the rotor plane; 6) site specific variation in wind speed & direction over time; 7) number of wind turbines and their spatial configuration on the landscape and; 8) variation in bird flight speeds and height profiles.

GIS- MODELING OF RADAR LINE-OF-SIGHT COVERAGE AND THEORETICAL LAND CLUTTER IN THE SMØLA WIND-POWER PLANT AREA

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Abstract

This study is a part of the BirdWind-project initiated by NINA in 2006. In order to aid avian radar operators in optimizing the radar location (in terms of coverage) without having to move around radar equipment and perform live tests, we developed a GIS-based model for line-of-sight studies and clutter identification. An optimal radar location is where the radar sees little clutter, while maintaining an unobstructed view to the area of interest at different altitudes. Thus a theoretical evaluation of new sites can be performed, and the best alternative chosen. The GIS-model is based on viewshed analyses relative to the actual radar location at different altitudes to identify the volume shadowed by the terrain in the anticipated radar coverage. The model also identifies ground clutter areas and calculates the clutter return by estimating the reflectivity properties of the terrain based on grazing angles and the scattering effectiveness of land cover. The land surface reflectivity of each radar resolution cell multiplied by its area gives the Radar Cross Section (RCS), and hence the land clutter echo. The model output correlates relatively well with the radar clutter image but seems to indicate minor underestimation. This can be related to potential errors in the digital terrain model, limitations in the constant gamma reflectivity model and the fact that the model only approximates any refractivity or diffraction effects. In addition to ground clutter the wind turbines themselves represent complex sources of radar interference. The modelled visible volume, ground clutter areas and expected interference areas can also aid the interpretation of radar data by identifying possible false alarms, and provide input to further analyses. The huge RCS combined with spatial and temporal variation of turbine interference makes it particularly difficult to handle for an automatic radar processor. In 2011, we will extend our model with a simple approach for turbine interference modelling.

DYNAMIC HABITAT MODELLING AS A MEANS TO ASSESS HABITAT DISPLACEMENT IN RED-THROATED DIVERS *GAVIA STELLATA* IN THE OUTER THAMES ESTUARY

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Abstract

The wintering range of the red-throated diver *Gavia stellata* overlaps with several strategic development zones for offshore wind energy. As habitat displacement from existing offshore wind farms has been documented for this species, innovative solutions are needed which can ensure the sustainable development of the industry in areas of high densities of divers. This paper reports on the development of a dynamic habitat model for predicting and mapping the abundance and distribution of Red-throated Divers in the Outer Thames Estuary. The study has been carried out in 2010 in support to the planning process for the London Array Offshore Wind farm. The main scope of the modelling activities has been to provide an independent and quantitative assessment of the risk to the regional (North Sea) wintering population of Red-throated Divers from the development of the wind farm. The model development covered the following milestones:

- Estimation of the importance of the wind farm site for wintering red-throated divers
- Estimation of the local population size within the Outer Thames Estuary
- Evaluation of the potential loss of suitable habitat and reduction in local population size arising from habitat displacement because of the wind farm
- Assessment of the significance of the impact of habitat loss at the level of regional population

The milestones have been achieved through the application of state-of-the-art high-resolution distribution models (two-step Generalized Additive Models) coupled to detailed hydrodynamic models. The distribution models were based on survey data supplied from aerial surveys from all existing and planned wind farms in the region. Habitat displacement was estimated using results from monitoring activities at existing wind farms. Significance of the impact of habitat loss was assessed using a threshold of Potential Biological Removal calculated from estimated minimum population size for the North Sea in combination with published data on life-history traits.

ASSESSING THE RELEVANCE OF BIRDS COLLIDING WITH OFFSHORE STRUCTURES

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Abstract

Environmental Impact Assessments aim to evaluate the effects of offshore wind turbines on migrating birds. Addressing open questions on migratory processes in relation to weather conditions, the risk of collision when flying in the reach of the turbine's rotor blades poses a serious threat to birds and is, thus, of paramount importance. Visual and acoustic observations, vertical and horizontal scanning radars, video systems and thermal imaging devices are currently in use for a long term monitoring study on the research platforms FINO1 at 'alpha ventus', Germanys first offshore wind farm, and FINO3. Data collection include species' identification, number of migrating birds at different heights and times, estimates of the birds headings, information on behavioural traits (i.e. evasive manoeuvres) and ultimately, the number of dead animals found on the research platform. Major difficulties in assessing the actual relevance of bird collisions are due to the fact that the numbers of dead birds found during a visit at the platform may really originate from several days past. In addition the number of casualties may be strongly underestimated when considering potential losses through predatory birds, heavy whether sweeping the carcasses off the platform, and the chance of a bird actually falling on to the platform after collision - good weather conditions provided. On November 5th 2010, 88 dead birds were found on FINO1 – a mass collision event subsequent to a documented mass migration four nights earlier. On this occasion it was possible to identify the actual date and time of the collision event and to observe what happened throughout that night via remote sensing techniques. The use of such devices, therefore, is imperative to allowing for a better alignment of actual and observed numbers of collision casualties and ultimately for better assessing the risk and relevance of bird collisions in general.

ASSESSMENT AND MITIGATION OF POTENTIAL WINDFARM IMPACTS ON THE THREATENED CRANE, *GRUS RUBICUNDA*, IN SOUTH-WEST VICTORIA, AUSTRALIA

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Abstract

South-west Victoria has some of the most prospective wind resources in Australia and is currently being extensively developed by renewable energy companies. Within this development area occurs a threatened population of the Australian crane, the brolga. Guidelines for the assessment, avoidance and mitigation of potential impacts of wind farm development provide standards for assessment of brolga populations, and recommendations for design and mitigation of any impacts. The overall approach is to avoid impacts as much as possible by recommending turbine-free buffers around essential breeding and flocking habitats, and quantifying and offsetting any unavoidable impacts using collision risk and population viability models. Impacts and offsets are quantified at individual developments with the aim that each development achieves a no 'net' impact on the Victorian population of the brolga. By requiring each individual wind farm proposal have no net impact on the brolga population, cumulative impacts of multiple wind farm developments on this species are avoided. An example of the use of these guidelines will be presented.

GPS TRACKING OF GOLDEN EAGLES ON PROPOSED WIND FARM SITES AND REFERENCE AREAS IN NORTHERN SWEDEN

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Abstract

In Sweden, large scale wind energy development may pose a threat to the golden eagle, a protected species which breeds throughout much of the northern forest region. Using GPS tracking, we aim to study the movements and ranging behaviour of golden eagles in five territories before and after wind farm establishment, and in five unexploited reference territories (i.e. using a *Before-After-Control- Impact, BACI*, approach). The aim of the project is to advise the wind energy industry on “eagle friendly” placement of wind farms. So far, five juvenile and eight adult golden eagles from seven territories have been fitted with solar-powered GPS units. Dispersal of juveniles in their first calendar year and wintering ranging behaviour of territorial adults will be presented, and used to discuss implications for wind farm establishment.

DO OPERATIONAL TURBINES CREATE A BARRIER TO WATERFOWL MOVEMENT IN THE PRAIRIE POTHOLE REGION OF NORTH AMERICA?

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Abstract

We conducted waterfowl flight behaviour surveys at the Crystal Lake II Wind Energy Center to assess whether the construction and operation of the wind farm affects waterfowl movement between two relatively large wetland complexes in Hancock and Winnebago Counties, Iowa. We conducted flight behaviour surveys at seven locations selected based on their proximity to the focal wetland areas and the wind farm turbines between these two wetland areas. We conducted the surveys during three periods: before wind farm construction (April 1 – May 7, 2008), during wind farm construction (September 27 – November 4, 2008), and following wind farm construction (April 26 – May 27, 2009). During each survey, the surveyor recorded all avian flights within a 400-m radius centred on the survey location. For each observation, the surveyor recorded species, number of individuals, average flight height and flight direction, and recorded the flight path onto data sheets for subsequent digitizing prior to analysis. The results suggest that the presence of operational turbines does not affect the ability or tendency of waterfowl to move between the wetland complexes. The proportion of birds observed that flew through the wind farm did not change once the turbines became operational, nor did the direction in which the birds were observed flying. The major difference between flight behaviour prior to and following the turbines becoming operational is that birds flying in the vicinity of the wind farm when the turbines were operating did so below the heights equivalent to the rotor swept area. This suggests that risk of turbine collisions will be low for those birds flying through the wind farm. The results (i.e., the shift in flight height profiles) suggest that waterfowl are behaviourally flexible with regard to their flight behaviour, at least over short commuting distances. This behavioural flexibility may contribute to the general observation that waterfowl are rarely reported as fatalities at newer generation wind farms.

A RISK MAP OF MIGRATORY RAPTOR'S COLLISION MORTALITY IN THE NATION-WIDE MIGRATION ROUTES

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Abstract

Grey-faced buzzard, *Butastur indicus*, a vulnerable migratory raptor, is faced to collision risk in the Japanese wind farms. However, no research was conducted with the effect of wind farms on the population viability. Reconciling with conservation of vulnerable raptors is an important matter in development of wind power generation.
Our objective is to develop the visual map of collision risk of a migratory species. The population size in the region surrounded by geological barriers, for example great mountain ridges, is estimated by referring to reports on distribution area and life history traits. The number of migrants at the certain section in the migration route was expressed as accumulated population size of the whole regions whose raptors migrate into that section. The number of migrants in each section was mapped with dataset of wind farms on the geographic information system (GIS) and analyzed.
According to our method, the estimated whole population size at the autumn migration season is 200,000. In some cases, concentrated migration route passes close to relatively dense wind farms.
Migratory species have broad geological distribution and distance between the sites where face to collision risk and the breeding site. That trait makes it difficult to see the relationship between impact of particular wind farm and consequence in population viability. Our modelling methodology can be applied to understand collision risk of those species. Therefore, it is useful to build social consensus about bird strike issue.

COLLISION VICTIMS AT WIND FARMS IN THE NETHERLANDS

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Abstract

With the increasing number of wind farms that are being built in the Netherlands, we have had the opportunity to study the number of birds that collide with turbines at eight different sites. In addition, we assessed the risks that wind farms may have for birds by determining flight intensities and flight paths with radar at a large number of planned wind farm locations.
Here, we present an overview of the results of these studies. Important aspects of the methodology are discussed, such as the necessity to correct for search efficiency and disappearance rate. The number of victims found under turbines on a yearly basis is discussed, as well as the species that are most commonly involved. These results are discussed in the light of the location of wind farms, and of the use of the area by birds. In addition, the effect of the size of turbines on collision risk is discussed, as well as the arrangement of the turbines within a wind farm.

METHODS TO OBTAIN FLIGHT PATTERNS OF BIRDS FROM OFFSHORE RADAR DATA

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Abstract

Flight patterns of birds were studied in the framework of a three-year effect-study in the Dutch Offshore Wind Farm Egmond aan Zee, following a two-year baseline study. Both visual observations and continuous radar observations were carried out between 2007 and 2010, to assess fluxes, flight altitudes and deflection of flight paths. A horizontal and a vertical radar, that were equipped with Merlin (DeTect Inc.) for automated data recording and processing, provided continuous data on flight paths, also during night time and adverse weather.
In addition to the results, that are shown in a separate presentation, we show here how data on flight patterns were recorded and validated. The offshore location resulted in a large proportion of sea clutter in the horizontal database. To remove this clutter from the database, we designed a filter based on the echo characteristics of the data. With this filter we could remove a large proportion of clutter data and yielded a database that consisted largely of bird echoes.
The Merlin tracking software provided possibilities for remotely controlling the radar and the recorded data. This allowed us to continuously monitor clutter conditions and flight activity of birds. The information thus obtained was used to validate our clutter filters, as shown in the presentation.
This study was commissioned by ‘Noordzeewind’ (a joint venture of Dutch utility Nuon).

THE EXTENT OF PHOTOTACTIC ATTRACTION OF NIGHT-MIGRATING BIRDS PASSING AN ILLUMINATED STEEL MAST IN THE WESTERN BALTIC SEA

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Abstract

The Baltic Sea is currently facing an unprecedented structural change due to the growing offshore wind-power industry. At the same time, the western Baltic represents one of the most frequented flyways of migratory birds in northern Europe. The increasing risk of birds colliding with offshore wind turbines is of significant conservation concern. Yet, when it comes to assessing the extent to which birds are affected by offshore structures that protrude into the open airspace, and that are illuminated by night, birds' immediate behavioural responses have only rarely been systematically documented and analysed. Predictive cumulative models on avian collision risk tend to focus more on stochastic processes than on individual behavioural responses. This oversimplification can lead (and has led) to unrealistic models with only limited predictive power and value for the development of preventative strategies. Here, we analyse the circumstances under which nocturnal migrants get attracted to illuminated vertical structures at sea and characterize individual behavioural responses. Since 2007, we have quantified overall migration rates at the research platform FINO 2 in the Baltic Sea, using conventional fan-beam radar. At the same time, we recorded small-scale movements of migratory birds (and bats) in close proximity to the steel mast of the platform, using a purpose-built motion controlled infrared camera system. Setting these videographic data in relation to the migration rates measured by radar, we can show that the number of nocturnal migrants that are attracted to artificial light increases with decreasing visibility. Thus, sea fog during twilight seems to represent the condition under which collision risk significantly increases. We discuss the sensory and behavioural mechanisms that lead to positive phototaxis in nocturnal passerine migrants. An in-depth understanding of these processes is decisive for developing lighting systems that reduce avian collision risk at human-built structures, such as offshore wind power plants. Funded by Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany (BMU)

ASSESSING IMPACTS OF WIND ENERGY DEVELOPMENT ON AIRBORNE FAUNA: ADVANCES FROM RADAR AEROECOLOGY

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Abstract

The increasing proliferation of onshore and offshore wind-energy developments pose threats to dispersing, foraging and migrating bats and birds. Assessment of such threats to local and continental scale movements of these airborne organisms requires precise knowledge of the location of wind-energy facilities. Ultimately, such knowledge can be used to help mitigate the adverse impacts of wind-energy facilities on airborne fauna. High reflectivity values of rotating turbine blades of utility-scale wind-energy facilities can be detected using WSR-88D NEXRAD (Next Generation Radar) Level II data derived from composite reflectivity images, which have been temporally averaged to reduce signals attributed to bioscatter, weather phenomena, noise, and so forth. Wind turbines can be resolved using the resulting two-dimensional reflectivity maps because they produce relatively persistent backscattered signal when depicted against developed landscapes. These depictions can be used to validate GIS databases of actual wind-energy facilities, which are compiled from a number of different sources. These same databases can also be used to depict patterns of dispersal, foraging behaviour, and migratory pathways of bats and birds adjacent to these wind-energy facilities when appropriately averaged in time. Additionally, the use of dual-polarimetric Doppler weather radars such as the NOAA X-band Polarimetric (NOXP) system makes it possible to determine the ratio of reflectivity, measured by horizontal and vertical polarization, to distinguish nightly movements of dispersing, aerial feeding insectivorous bats and birds from airborne insects upon which they feed. We suggest that local and dynamic continental-scale data on nightly and seasonal movements of birds and bats, detected by NEXRAD Level II data, in proximity to existing wind-energy facilities, or to facilities under development, should be used to inform the wind-energy industry with respect to where and when airborne fauna are at risk of being killed by wind turbines.

SPANISH EXPERIENCES ON WINDFARMS AND BIRDS

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Abstract

The development of wind energy is a central component on the objective of reducing the greenhouse effect and the Spanish government is committed to ensure that 12.1% of the used energy will be generated from renewable sources by 2010. Nowadays Spain has more than 737 operational wind farms, comprising 16,842 turbines and more than 16 GW installed.
Three adverse effects on birds have been described regarding wind farms: 1) direct habitat loss during the construction of the wind farm; 2) disturbance during construction and post-construction (more problematic); and 3) bird mortality for collision with turbine blades. The rate is the number of bird collisions with a turbine blade per year, and they are relatively low, although in some cases the amount could cause concern.
To prevent bird collision in new build wind farms is a critical issue. When a wind project is proposed, an environmental impact assessment (EIA) is required by Environmental Authorities, and must include a section assessing the impact that the development is likely to have on the development site's bird populations (EIA Directive 97/11/EC). The baseline data collection must be adjusted to different requirements depending on the areas, so a fixed baseline survey is not possible.
We studied the mortality data of two wind farms and the bird abundance. Our results show the mortality was constant throughout all study period, and the mortality was not in relationship with the abundance. Griffon vulture was the species most frequently killed. We used failure time analysis to known what variables were more important in mortality. So the results were the species-specific flight behaviour, weather conditions and topography around the wind farm.
Other study is about the relationship between risk assessment studies and recorded mortality in post-construction. We have the dangerous index of several species in different areas pre-construction, the bird abundance and density, the number of bird flights at blades height and the mortality data every day for 2 years. And our results indicate there is no relationship between the birds in risk in pre-construction and the mortality data in post-construction.
So what happens, and are there solutions? We think the first solution could be improved EIA. It is necessary to take all variables during the pre-construction phase (with all of the most frequent kinds of winds) and knowing the exact position of the turbines.
Other solution could be to predict griffon vulture flight trajectories to avoid mortality in wind farms (in pre-construction state), using simulated wind currents. We simulated three different types of wind and we noted the main trajectories. Afterwards, we compared these main trajectories with the real griffon vulture movements in the same area. And we found no statistical differences between the observed griffon vultures' flight trajectories and the three wind passages observed in our wind tunnel model.

HOME RANGE OF FEMALE PEREGRINE FALCONS (*FALCO PEREGRINES ANATUM*) DURING THE BREEDING SEASON IN SOUTHERN QUEBEC, CANADA

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Abstract

In Eastern Canada, the province of Quebec is currently promoting the development of its potential for wind energy generation. By 2015, several wind power facilities will enter in operation. In North America and Europe, negative impacts of wind power facilities on birds of prey have been well-documented. Peregrine falcons are particularly sensitive to the presence of wind turbines, because the species is susceptible of flying at an altitude propitious for blade-strike mortality. In order to evaluate the potential risk of the expansion of wind power facilities on this species in Quebec, it is essential to define its habitat use during the breeding season. Therefore, the two main objectives of our study are to determine habitat types influencing home range size and to identify which habitat types are selected by peregrine falcons during the breeding season. Seven female peregrine falcons were tracked by satellite transmitters during 2009, throughout the incubation, the rearing and the post-fledging periods. Our preliminary results showed that the home range of peregrine falcons tracked by satellites increased in size from incubation to post-fledging period. Also, an increase in the proportion of farmlands within home ranges resulted in a significant increase on their size. Also, we were not able to detect any signification difference in the selection of each habitat types (wetlands, farmlands, urban areas, others) at the 95 % confidence level. The distance of a habitat patch from the nest was amongst the most important variable to explain the selection by a falcon. Since 95 % of the locations were within 15 km of nests, our results show that a zone of at least 15 km around each nest may be considered at risk from wind power facilities during the breeding season.

VARIATION IN HOME RANGE USE RESULTS IN DIFFERENTIAL VULNERABILITY OF BALD AND GOLDEN EAGLES TO WIND TURBINE COLLISION ON THE BREEDING GROUNDS

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Abstract

Golden eagles (*Aquila chrysaetos*) and bald eagles (*Haliaeetus leucocephalus*) are designated as vulnerable species in Québec, Canada, where increasing numbers of wind facilities are planned over the next five years. Many of these facilities will be sited close to known nesting sites of these two species which will then face the threat of wind turbine collision. In situations where nests are within 20 km of a wind facility, eagles are required to be captured and equipped with a telemetry device. To identify adequate turbine siting and the necessity of other mitigation measures, home ranges of individual birds are delineated. Preliminary results indicate variation in home range use between the two species that may lead to differential vulnerability to collision. First, due to prey selection which limits foraging to large water bodies, bald eagles have relatively smaller home ranges than those of golden eagles. Secondly, within breeding and post-breeding season, use of the home range by bald eagles is relatively consistent whereas golden eagles frequent a varying number of core areas distributed within their home range among which they gradually switch. We also evaluated differential patterns in flight altitude by the two species of eagles within home ranges, in the context of potential risk from turbines. The differential behaviour and home range use between golden eagles and bald eagles will be discussed in relation to number of mortalities of these species reported from wind facilities.

A CASE STUDY OF THE INTERACTION BETWEEN LANDSCAPE CONFIGURATION AND HABITAT USE AT A WIND FACILITY BY GOLDEN EAGLES (*AQUILA CHRYSAETOS*)

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Abstract

Wind power is expanding all around the world and the province of Québec, Canada, plans to increase its production from about 500 MW today to 2000 MW in 2012 and to 4000 MW in 2015. Some wildlife species are highly vulnerable to blade-strike mortality and golden eagles (*Aquila chrysaetos*) are known to be one of those. Not all wind facilities present the same risk of mortality; windmill configuration and site particularities are two major parameters to take into account when evaluating such risks. The present study aims to determine how habitat configuration affects space use of breeding golden eagles, with a particular focus on areas adjacent to wind facilities. We hypothesized that a higher amount of open habitats in the vicinity of wind farms will increase the use by golden eagle of the wind facility. Our study area is located in the Gaspé peninsula of Québec. Golden eagles were tracked with GPS telemetry. Preliminary results show that nests close to areas with high proportion of open habitats had smaller home ranges and individuals were less likely to use open habitats surrounding wind farms. Where availability of open habitats near eagle nests is lower, openings created near and around wind facility offer new hunting areas, increasing the likelihood of use by golden eagles and thus increasing potential risk to birds of blade-strike mortality. Hence, developers aiming to establish wind farm projects in forested mountainous areas, as is the case for many projects in Eastern North America, should consider that creating openings within a forested habitat may increase collision risk for golden eagles. Creating openings by planning forest cuts in the vicinity of nest sites could be experimented to see if this may shortstop eagle movements and reduce attraction to wind facilities and collision risk.

RED KITE (*MILVUS MILVUS*) FATALITIES AT WIND TURBINES – WHY DO THEY OCCUR AND HOW THEY ARE TO PREVENT?

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Abstract

More than half of the world population of the red kite (*Milvus milvus*) breeds within Germany resulting to a high national responsibility for the species. Germany has also ambitious plans to increase the proportion of energy production generated from wind power, but Red Kites are the second most commonly found species as collision victim at wind turbines on a national level.
2007-2010 the research project “Birds of Prey and Wind Farms: Analysis of Problems and Possible Solutions” took place. It was financed by the German Ministry of the Environment, Nature Conservation and Nuclear Safety and coordinated by the Michael-Otto-Institute within NABU. For the Red Kite the main aims of the project were to understand when, where and why these birds are at risk of collision with wind turbines and to develop measures to minimize collision frequencies.
Data collection for Red Kites took place at 5 study sites in Saxony-Anhalt, the federal state with the largest population. The main activities were standardized observations of flight behaviour and habitat use within and outside of wind farms. To receive individual data on home ranges, flight distances and daily activity radio transmitter and GPS transmitter were attached to Kites breeding next to wind turbines.
Key factor for the choice of the hunting habitats is the agricultural management. Red Kites do not avoid wind farm areas and if there are attractive hunting habitats the Kites use these and come close to the turbines. Red Kites also fly often in the height where the rotor rotates. Otherwise the used area is highly individualized. Home ranges may be very small or quite large and do not only depend on habitat quality because breeding partners may show different strategies too. Often specific food resources like settlements, compostings, boundary structures or cutted fodder plant fields are used.
In order to minimize collision risks for Red Kites it is useful to keep the surrounding of the nest sites clear of wind turbines up to a distance of at least 1.000 m, to restrict the agricultural management activities inside of wind farms (e.g. no mowing before Mid of July) and to keep the rural areas around the turbines as unattractive as possible.

BEWARE OF THE DOG!

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Abstract

Dogs (*Canis lupus familiaris*, Linnaeus) have been used for decades to assist humans, and their use for wildlife surveys is of increasing interest to scientists and wildlife managers. Such interest increases when conservation programs are implemented for endangered species. Considering that the number of wind turbines has more than doubled since 2005, and is expected to continue to increase in future years (WWEA, 2009), the conservation of birds and bats deserves high priority.
Aware of this problem, Bio3 established a pioneering protocol with the Special Operations Group of the Portuguese Public Security Police (PSP) – K9 Unit, to train handlers and detection dogs to form dog-handler teams. From April to July 2008, a two year-old female German Shepherd and a four year-old Labrador Retriever were trained, using similar techniques to those used on narcotics, explosive, search and rescue detection dogs. The handlers' training consisted in dog driving, body language interpretation and assisting the dog to work with the odour source. After the trainee, both dogs were able to stay point and bark in the presence of a bird or bat carcass.
After this successful experience, Bio3 is using such incredible "detection-weapon" in biodiversity surveys. Currently Bio3 promotes operational and research work with detection dogs, to improve its application on ecological studies. This method has been used throughout Portugal, by Bio3, to monitor the impacts of wind facilities in avian and chiropteran fauna, and the company expects to expand this service to all Europe and worldwide, establishing partnerships with local entities. Additionally, scientific research carried out by Bio3 regarding the accuracy and efficiency of detection dogs was reviewed and published in an international peer-review journal.

POST CONSENT MONITORING OF WINTER GOLDEN PLOVER FLIGHT ACTIVITY IN RELATION TO OPERATIONAL WIND TURBINES

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Abstract

This study involves a combination of field investigations at proposed and constructed wind farm sites across the UK, and desk studies using pre- and post-consent data on golden plover flight behaviour collected for wind farm EIAs and other studies.
Research objectives are
• To assess the use of wind farm sites by wintering golden plover.
• To assess the flight behaviour around turbines.
• To assess the proximity of diurnal and nocturnal flocks to turbines.
Monthly vantage point watches and day and night time walkover surveys were conducted between September and March over 2 years at five UK wind farm sites to record:
• Seasonal variation in site-use.
• Flock size.
• Flight height.
• Proximity of flights, feeding and roosting to turbines.
An index of flight activity in relation to proximity to turbines was calculated for four distance bands around the turbines: 0-50m, 50-100m, 100-200m and 200-500m. The flight activity indices were analysed to identify whether there were lower rates of flight activity within 50m or 100m from turbines.
Using Monte Carlo randomisation techniques the analysis shows that flight activity within 50 and 100m of turbines is lower than randomly-selected areas. These analyses involved randomly reallocating response values as being either within the turbine buffers or the random point buffers.
The potential threat to the conservation status of the golden plover is highlighted in a recent report suggesting that 1.4% of the British population are estimated to occur within the footprints of consented and proposed wind farms. This study aims to complement existing studies on plover interactions with wind farms and help inform future impacts.
The need for further research on this species has been highlighted by cases where the lack of knowledge on golden plover interactions with wind farms has been an obstacle to their development.

BIRDS, BATS AND SMALL WIND: TESTING THE EFFECTS OF SMALL WIND TURBINES ON BIRD AND BAT ACTIVITY

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Abstract

Both national and international targets to reduce carbon emissions have led to the rapid expansion of renewable energy technologies worldwide. Although the effects of large scale wind farm developments on wildlife are increasingly well documented, the effect of small- or micro wind turbines on wildlife have not been quantified. Due to differences in scale and siting, potential impacts are likely to be different to those of large wind farms. Combined with the increasing availability of small wind technologies to private home- and landowners, understanding their effects on wildlife has become crucial. Here we present preliminary results of our study of small wind turbines on the activity of birds and bats at 18 sites in the UK. Bird flight lines and behaviour were recorded using vantage point observations. Bat activity was recorded using automated detectors at each turbine and at a nearby "control" site. We assess the influence of turbine setting, habitat structure and turbine operation on flight distance and bat activity. We also compare bat activity between the "turbine" and "control" sites. We discuss these preliminary results in the context of findings from studies of large wind farms, and discuss the potential implications for site selection and planning permission for small wind turbines.

LANDSCAPE USE ON DIFFERENT SCALES AND MORTALITY RISKS OF JUVENILE WHITE-TAILED SEA EAGLES AT A WIND-POWER PLANT AREA IN COASTAL NORWAY, REVEALED BY GPS SATELLITE TELEMETRY

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Abstract

At the island of Smøla, Western Norway, at the site of a 150 MW, 68 turbine wind-farm, 59 juvenile white-tailed eagles were satellite-tagged 2003-2010. From August 2005 (when searches for dead birds started) to January 2010, four of these were killed by collisions with turbines, out of a kill of 39 white-tailed eagles in total, involving 16 adults, seven immatures and six juveniles. Two of the satellite-tagged juveniles were killed first autumn, while the two others were killed the next spring. Both sexes stayed within the Smøla area during their first winter, involving collision risk with the turbines. Both sexes moved away from the area during spring in their second year (March-April). Females dispersed further than males, often more than 800 km during summer, generally to the north. There was a return movement to the natal area during the second autumn, involving further risk of turbine mortality. The same pattern was repeated in the third and fourth year for females, while the males showed more philopatry. The use of night roosts in the vicinity of the wind-farm seems to pose an added risk. A method for risk assessments based on GPS locations is proposed. The findings have implications in the context of population viability locally, and to the viability of the white-tailed sea-eagle population as a whole seen in the context of future wind-farm plans and developments along the Norwegian coast.

A SIMPLE AND QUICK METHOD FOR MAPPING BIRD DENSITIES TO ASSESS DISPLACEMENT

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Abstract

In order to know when displacement due to an offshore wind farm is occurring, it is necessary to have a good idea of the numbers and distribution of birds. Boat and aerial surveys are carried out before, during and after construction to look for any shift in bird distribution. However, detecting patterns in raw observations can be difficult and distance sampling methods only provide a population estimate at the scale of the survey block. Kernel density estimation (KDE) is a simple, quick and cheap method for smoothing raw observations, facilitating an understanding of bird numbers and patterns at scales smaller than the whole survey block. It produces maps of bird density that are easily interpreted by non-scientists.

THE USE OF DOGS TO PERFORM MORTALITY SEARCHES: COST EFFECTIVE AND EFFICIENT

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Abstract

Mortality searches can be costly and time consuming. Large wind farms aiming to monitor mortality impacts with some degree of scientific credibility need to survey vast areas each day. For example, a search radius of 100m around a turbine equates to over 3 hectares of area. A human surveyor searching 2 meters visually either side would walk 7.5km to cover 3 hectares, whilst a dog and handler using a 5m retractable lead walks only 3km to search intensely the same area. Off lead, it has been demonstrated that a trained dog can search an area of 3 hectares efficiently in less than 20 minutes and detect all carcasses present.
Several breeds of hunting dogs have been employed on a regular basis to perform routine mortality searches at a number of wind farms in Victoria, Australia. An initial trial in 2005 with a German Shorthaired Pointer indicated that dogs were more accurate than human surveyors (91% compared with 54%) and faster (18 minutes compared with 35 minutes for 50m radius around turbine). Subsequently, 2 Pointers and 2 Labradors have been employed on a regular basis and have been undergoing searcher efficiency trials for five years. It has also been demonstrated that dogs use primarily scent to locate remains and thus hidden, obscure or partial remains are more readily detected by dogs then humans. Dogs have proven to be efficient and cost effective in undertaking mortality surveys and their use at Australian wind farms is becoming standard practice.

INTEGRATED ORNITHOLOGICAL MONITORING PROGRAM FOR OFFSHORE WIND FARMS

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Abstract

We recommended that a basis for structuring ornithological baseline surveys for offshore wind farms is to build up an appropriate understanding of the site through an Integrated Ornithological Monitoring Program (IOMP). This IOMP should use a selection of complimentary techniques targeted towards the range of species highlighted as being at potential risk. These techniques may include boat-based and aerial surveys, complimentary remote methods such as radar and tracking studies, and then modelling approaches such as collision risk, population viability analysis and cumulative impact assessment. The poster will present this approach using a case study of the ornithological work currently being undertaken for the proposed Moray Firth Offshore Wind Farm off the UK.

HABITAT MANIPULATION OF FARMED LANDSCAPE, IS THIS A COST EFFECTIVE MITIGATION MEASURE TO REDUCE RISK TO BATS FROM WIND FARMS IN LOWLAND ENGLAND?

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Abstract

The level of bat activity in lowland England has been shown by several studies to be strongly influence by the land-use and type of farming (intensive arable, livestock framing, dairy, beef, sheep) organic or non-organic. Hedgerow structure, species composition, location of ponds and presence of hedgerow tree can also strongly influence bat use of landscape. Use of agrochemicals can dramatically influence the abundance of insect prey and therefore foraging behaviour of bats. The economics of farming in is influenced by international commodity prices as well as national farming support schemes and agri-environment policy. Income from a wind farm can stabilise income for individual landowners and provide opportunities to change the management of the farmed landscape. This paper examines the potential opportunities, finance costs (including loss of productive land, agrochemical costs and ongoing management) and barriers to manipulate the farmed landscape, within and outside proposed wind farms, to influence bat forging patterns and therefore reduce potential risk to bats. This paper draws upon pre-application surveys on a number of potential wind farm sites in England and sets out proposed habitat manipulation and management schemes to be implemented on these sites subject gaining planning permission and set out a proposed monitoring scheme to test long term impact of such schemes.

MAPS OF SENSITIVE WILDLIFE HABITAT AREAS - KEY STEPS TOWARD GREEN FACILITY SITING

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Abstract

As renewable wind energy generation facilities are being planned, one of the first questions that should be asked is “Where can these facilities be sited such that they will have minimal environmental and conservation impact?”
A new map of wind-sensitive wildlife habitat areas for the U.S., being prepared by The Nature Conservancy under contract with the American Wind and Wildlife Institute, can serve as a first resource to utilize in siting wind, and other infrastructure facilities. The map is intended to provide information at a coarse scale on the potential locations of wildlife species that may be sensitive to direct mortality or habitat fragmentation effects from wind facilities.
At an individual wind facility siting level, Oklahoma has developed a spatial planning tool (models and maps) for species particularly sensitive to habitat fragmentation impacts from new wind energy facilities and other infrastructure. The tool was developed at a high-resolution scale using information specific to the species being evaluated, their habitat needs and the condition of potential habitats on a statewide basis. From those factors, maps depicting where wind energy facilities could go without significant impacts and where the most important habitats currently exist were developed. Potential mitigation values were also assigned to habitat areas, in the event that impacts are unavoidable.
Both the U.S. and the state map tools are available via web access to wind developers for their use in, first, coarse scale and then fine scale siting of planned facilities to assist in avoiding, minimizing and mitigating impacts of their facilities to sensitive species. The maps are also used by conservation entities to focus mitigation strategies toward the highest priority areas. The creation and use of both maps will be explained.

A MULTI-METHOD APPROACH TO DETERMINE THE IMPACT OF EXISTING WIND POWER PLANTS ON BIRD AND BAT MIGRATION ON THE ISLAND OF FEHMARN, GERMANY

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Abstract

The island of Fehmarn, situated off the German Baltic coast, is well-known for being a hot-spot for bird migration. It is assumed that about 100 mio. Scandinavian birds cross the island each year using the shortest connection between the South of Sweden (Falsterbo), the Danish Baltic islands and the German mainland. On the other hand there are already four major wind farms located on Fehmarn. Moreover, there are plans for more and higher wind power plants. To investigate the influence of the existing wind farms on bird (and bat) migration and to be able to assess the possible impact of future developments, a comprehensive research project was carried out in 2009. It comprised five subprojects using different methods:

- The number of migrating birds at different heights – especially at night – was determined with two vertical radar installations at different locations.
- Daytime bird migration was recorded simultaneously using six observers distributed over the island.
- Staging birds were mapped once a week covering Fehmarn almost totally to investigate the spatial distribution in relation to the wind farms.
- In the autumn period a systematic search for collision victims under 65 wind turbines was conducted and search efficiency and carcass removal by scavengers was estimated by experiments.
- Bat activity was registered with automatic ultrasound recording at hub height and ground level.

The results show that bird and bat migration over Fehmarn is hardly affected by the existing wind farms. Nocturnal bird mass migration occurs mainly at heights far above the turbines and only in adverse wind conditions the flight altitudes were lower. Birds migrating during daytime are obviously able to recognise wind turbines as obstacles and avoid them. The numbers of collision victims are not higher than in other areas. Staging birds like geese and waders avoid feeding and resting within or close to wind farms and are therefore affected by habitat loss. Bat activity and collision numbers were very low. In conclusion there are possibilities for further developments of wind farms on Fehmarn, if the favourite resting areas of geese and waders are taken into account.

OPTIMIZING SEARCHES FOR BIRD COLLISION FATALITIES WITHIN A WIND-POWER PLANT AREA BY USING TRAINED DOGS

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Abstract

Background: One important bias when estimating bird collision fatalities is the number of dead birds or dead bird remains overlooked by the observer. In general the area within a wind-power plant is searched for dead birds (and bats) by one or more persons walking in a fixed pattern searching visually. At the Smøla Wind Power Plant dogs were used to locate dead birds and bird remains.
Research objectives: The objectives were to improve the search accuracy, and subsequently the basis for future estimates of the total bird fatalities within the wind-power plant area, and compare the search efficiency between the dogs and the dog handler.
Methodology: Two dogs were trained to find feathers and bird remains during summer 2006, and were used at weekly searches over a four year period. The numbers of bird casualties found by each dog and by the dog handler were compared. The dog performance were also tested by their ability to locate artificially placed dead bird objects.
Results: The dog's ability to locate the objects (i.e. dead bird remains) they initially were trained to, proved to be superior compared to human vision. And during the searches on Smøla the dogs were significantly better to find dead birds and feathers than the dog handler (98 versus 47 objects; $\chi^2 = 17.9$; d.f. = 1; $P < 0.001$). By using dogs we have estimated that more than 50% of the casualties remaining in the search area were found by the dogs, but varying in distance from turbine.
Discussion: Differences between human vision and dog olfactory sense are discussed as a basis for use in searches for dead birds and bird remains. Based on the results from Smøla differing field procedures are discussed, including the training of dog search image.
Implications: Searches by dogs are more efficient and cover the search area in shorter time. Dogs trained to searches will be the best method to locate fatalities at wind turbines.

TURBINE-INDUCED BIRD MORTALITY AT THE SMØLA WIND-POWER PLANT – SPECIES-SPECIFIC ESTIMATES

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Abstract

Background: Smøla is the largest Norwegian wind-power plant with 68 turbines. Due to recordings of several dead white-tailed eagles (WTE) within the power-plant area in 2005 and 2006, and a general poor knowledge on bird impacts from wind power generation in Norway, NINA initiated a 4-year research project (BirdWind) (2007-2010) based on funding from the Research Council of Norway.
Research objectives: A main objective of the BirdWind-project has been to study species-, site- and seasonal-specific bird mortality; and to identify vulnerable species and site-specific factors that should be considered to improve the basis for future pre- and post construction EIAs in connection with wind power-plant constructions.
Methodology: Since August 2006 two dogs, trained to search for dead birds, together with a dog handler, have conducted weekly searches for bird casualties at a selection of 25 turbines. The remaining 43 turbines have been searched once each month. Removal and search bias experiments have been carried out.
Results: Since regular searches were initiated in 2006 a total of 35 dead eagles have been located within the power plant area, i.e. an annual average of 7.6, ranging between 2 and 11 per year. A total of 74 dead willow ptarmigan have been found within the wind-power plant area. This includes birds found dead during the regular turbine-related searches (more than 50), radio-tagged birds found dead after they ceased to move, and birds found by occasion. Between 10 and 15 specimen were found at the turbines each year. Another 65 specimen of at least 25 species have also been identified as collision victims, between 12 and 15 annually. Most common were common snipe, golden plover and hooded crow.
Discussion: Because of weekly searches with dogs and few scavenger species able to remove eagles from the search area, close to all dead eagles may have been recorded. Thus, the possibility of wounded eagles able to move out of the search area seems to be the main (only?) biasing factor. The removal rate experiments are as yet not concluded, however, for all species (except the eagle) the removal rate seems to be particularly high during the first 24-48 hours. Thus the final estimates will be higher than the preliminary ones.
Implications: The regular and frequent dead-bird search regime have located a majority of the bird casualties within the wind power-plant area, and given unique qualitative and quantitative information on species-specific bird mortality in space and time. The data are important contributions to predicting bird-safe siting of future wind-power plants along the Norwegian coastline.

BIRDMONITOR: DEVELOPMENT OF A NEW ANALYSIS TOOL FOR RADAR BIRD DETECTION

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Abstract

The use of radar technology in bird monitoring presents several advantages, such as wide range detection, accurate flight height and trajectory representation, and operation capabilities under unfavourable weather or light conditions (e.g. during night or fog). Radars have been increasingly used in environmental assessment studies (e.g. wind farms), evaluation of bird strike risk in airports and migration research.

The analysis of radar data may be extremely time and resource consuming, since radars may allow for the collection of huge data sets, during prolonged periods of time. Data analysis may be done manually, through the inspection of obtained images, or automatically, using some of the already commercially available software tools.

We have developed a new software application – Birdmonitor - for analyzing data collected by radars in bird and bat studies. It incorporates signal-processing technology and advanced tracking algorithms that optimize automatic detection, tracking and classification of bird targets. Innovative components of this tool include its iterative and interactive features, allowing full control and perception of the obtained results. Birdmonitor allows for the iterative definition of filters to eliminate clutter of different origins (ground, plains, insects) and for visualization of classified targets and routes following an interactive procedure. These characteristics allow site-specific adaptability, rendering very high detection efficiency and reducing significantly errors in target classification.

Birdmonitor also includes a database management system that stores very large datasets of georeferenced individual flight trajectories and associated parameters that allows data export for robust statistical analysis, including on the classification of species or groups of species.

We present data on the performance of Birdmonitor applied to different conditions, namely in a full year study on bird movements in an area proposed for the installation of a big airport and in a study on bird migration at a wind farm area.

FLIGHT ACTIVITY AND BREEDING SUCCESS OF HEN HARRIER AT PAUL'S HILL WIND FARM IN NORTH EAST SCOTLAND

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Abstract

This paper presents the results of an investigation into the impacts of an operating wind farm on the breeding success and flight activity of breeding hen harrier, *Circus cyaneus*. The hen harrier is an endangered raptor in the UK and a European protected species whose habitat frequently overlaps with wind farm sites in the UK leading to potential displacement. Paul's Hill wind farm, a 28 turbine site (64.4 MW) in North East Scotland was built on dry heath and blanket bog habitat. A moorland management plan is in place to protect the breeding hen harrier population. Data for nest location, breeding success (number of fledglings) and flight activity has been collected for a total of 9 years during the baseline, construction and operational periods. Collision monitoring has been undertaken during the first 5 operational years. The average number of hen harrier pairs breeding within the study area has remained stable during both the baseline and operational periods. It was also shown that the construction of the wind farm over a two year period had no negative impact on the number of breeding pairs or on breeding success, both of which were above average for these years. Initial results from the study support the conclusion that where traditional nesting areas are protected as part of a management plan, hen harrier will not be deterred from nesting in close proximity to an operating wind farm. At this site, hen harrier also shows avoidance behaviour of the turbines. Future sites that are planned in the vicinity of hen harrier nests should consider the need to manage suitable areas of foraging and nesting habitat for this species instead of focusing on the collision risk which this study, together with a number of others within the UK, suggests is negligible.

MITIGATION AND COMPENSATION: REVIEW OF HEN HARRIER BREEDING AND FLIGHT ACTIVITY NEAR A WINDFARM IN ARGYLL

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Abstract

Background: Cruach Mhor wind farm is located on the Cowal peninsula in Argyll, western Scotland. It was constructed in 2003/2004 and comprises 35 turbines with a combined capacity of 30MW. A pair of hen harrier *Circus cyaneus* was recorded at the site during the surveys for the development in 2001. In order to mitigate potential impacts, a 223ha Habitat Enhancement Area (HEA) was created adjacent to the wind farm.
Research Objectives: To determine whether flight activity or nest location of a pair of hen harrier changed during wind farm operation. To assess whether the mitigation measures for hen harrier were successful.
Methodology: Surveys of breeding success of hen harrier were undertaken between 2003 and 2010. Vantage point (VP) surveys to record flight activity were also undertaken in 2001, 2005, 2006 and 2007. Additional data on the abundance and distribution of key prey species were also collected. A Kernel Density Analysis of locations was used to predict usage of the area within the wind farm and HEA.
Results: In 2001, 37.6% of flight activity occurred within 500m of turbine locations. During 2005-2007, the proportion of flight activity within 500m of operational turbines was slightly higher at 40.9%. Flight activity also increased over the HEA during operation from 32.2% in 2001 to 42.4% during 2005-2007. The abundance of key passerine prey species meadow pipit and skylark was not significantly different between the wind farm and HEA over the same period. Over the period 2003 – 2010 there were a total of 16 hen harrier nesting attempts. Twelve nesting attempts occurred within 500m of operational turbines and four attempts within the wider HEA.
Discussion:

1. The Habitat Enhancement Area provided as mitigation for the wind farm development has increased in usage by hen harrier compared to before construction (32.2% and 42.4% respectively). This is likely to be due to significant change in habitat type as a result of commercial forestry felling.
2. Flight activity within the wind farm has been relatively consistent before construction compared to during operation (37.6% and 40.9% respectively).
3. Prey availability between the HEA and wind farm area is not significantly different.
4. Proximity of nesting locations to the wind farm has been consistent between years and does not show any evidence of displacement.

PATTERN OF BAT FATALITIES AT WIND TURBINES IN EUROPE: COMPARING NORTH AND SOUTH

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Abstract

At present (October 2010) > 3300 fatalities, belonging to 27 species (among 47 species present), are known from wind turbines in Europe. Most data are from two regions a) Germany and surrounding countries in the north and b) southern France and the Iberian Peninsula in the south. The data is extensive enough to allow comparisons between the two regions. The distribution of fatalities among species is highly skewed, but shows the same pattern in both regions. Most (> 90%) fatalities belong to open-air species of the genera *Pipistrellus* (in the broad sense) and *Nyctalus*, and very few (< 2%) to the genera *Myotis*, *Plecotus* and *Rhinolophus*. Surprisingly, the most extreme high-altitude bats *Tadarida teniotis*, *Miniopterus schreibersii* and *Nyctalus lasiopterus* are rarely killed. The seasonal pattern was bimodal in both regions, with one peak in early summer (May) and another in late summer (August) and a period with few fatalities in between. However, in the north most (90%) fatalities occurred in late summer, while in the south the two peaks were more similar in magnitude. Data from both regions suggest that most deaths at wind turbines occur either on top of hills and ridges or at the coast, while relatively few bats are killed at turbines on flat and open farmland.

THE MUD SHRIMP *CALLIANASSA SUBTERRANEA* AND ITS CONSEQUENCES FOR EIA

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Abstract

One aim of an Environmental Impact Assessment (EIA) is the mitigation of human impact on the environment of concern. Problems may arise if knowledge about species is low especially if they are protected. In the marine environment knowledge on which experts base their EIA comes from basic research and locally based standard investigations. However, to evaluate environmental impacts at the species and ecosystems level, knowledge of single species can be insufficient, as exemplified by the discussion on the impact of different offshore wind turbine groundings (e.g. monopile, tripod foundation and especial the gravity foundation) on the mud shrimp in Germany. Our investigations show the necessity for an adequate sampling design and the importance of international collaborations between operating companies, governmental authorities as well as scientists, to enable access to all data collected within EIA procedures to experts and scientists. In sum, these data would provide information that is currently unavailable and not considered for cumulative risk assessments. Based on more than 12.000 samples of benthic organisms, we show how knowledge about the spatio-temporal distribution of species and communities, in this case *Callianassa subterranea*, can increase.

APPROPRIATE ASSESSMENT OF PLANS AND PROJECTS FOR CROATIAN NATIONAL ECOLOGICAL NETWORK – UTILIZATION OF BIRD AND BAT IMPACT ZONATION IN THE SOUTHERN COASTAL PART OF CROATIA

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Abstract

Croatia in the process of accession to European Union established the National ecological network and Nature impact assessment procedure. National Ecological Network was a base for preparing NATURA 2000 proposal. In the process of issuing building permits each wind farm has to pass Appropriate Assessment procedure for National Ecological Network, which is a part of Environmental Impact Assessment. For the purpose of helping authorities in this process, project COAST (Conservation and Sustainable Use of Biodiversity in the Dalmatian COAST through Greening COASTal Development; UNDP-GEF Project 00050301) engaged experts for birds and bats to prepare zonation maps of the COAST area. COAST area encompassed 4 counties in Dalmatian region, whose spatial plans envisaged 75 locations for construction of the wind power plants. In Dalmatian region there are 18 internationally important bird areas (Special Protection Areas – SPA). Wind farms are planned in 12 of them. Also, in Dalmatia there are 261 areas important for wild taxa and habitat types (Sites of Community Importance - SCI). Wind farms are planned in 53 of them. Zonation of areas for birds has been made on the base of known distribution for the birds most threatened by windmills in Croatia - golden eagle (*Aguilla chrysaetos*), short-toed snake-eagle (*Circaetus gallicus*) and areas of transit for larger birds, especially cranes (*Grus grus*) and birds of prey. Zonation of areas for bats has been made on several criteria: type of colony (nursery, hibernating, migratory), size of colony, species composition on the site and potential migration routes. For this purpose, 9 of 12 species of bats from the Annex II of the Habitat directive have been analyzed. 3 zones were established for each group. General guidelines for research, mitigation measures and monitoring had been given for all zones prepared for birds and bats.

EVALUATION OF A LONG RANGE ACOUSTIC DEVICE (LRAD) FOR BIRD DISPERSAL AT EL PINO WIND PARK, SPAIN

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Abstract

The Cadiz province in southwest Spain contains one of the most important bird migration bottlenecks in the world, a peninsula of land which creates the shortest route for soaring birds to reach the African continent. The area is rich in wind resources as well as avian species, and as a result wind energy development in this province has resulted in greater avian collision risk and mortality, particularly of soaring birds. In an effort to reduce this risk, we tested whether a Long Range Acoustic Device (LRAD) could disperse birds away from high risk areas in TORSA's El Pino Wind Park, with an ultimate goal of reducing high avian collision risk and mortality.

The primary target species of this study was the griffon vulture (*Gyps fulvus*). The LRAD test was conducted January 11 – 22, 2010 at strategic locations in the wind park where avian pathways provided the best opportunities to apply the stimulus on this species. Reactions to 16 different LRAD sounds were recorded either by human observers or video camera, and later categorized by presence as well as strength of reaction. Preliminary results include analysis of bird flight behaviour before, during and after stimulus, and effectiveness of different LRAD sounds in dispersing birds. Important factors associated with a bird's reaction were distance of bird from the sound source, bird altitude, and number of individuals in a flock.

This study provides important information for the development of a real-time, on-demand LRAD mitigation system, and is the first in a three phase process to develop and implement LRAD harassment as an effective mitigation tool at wind parks. Next phases will make LRAD harassment more species specific, refine the sound delivery system, test for habituation and thresholds, confirm effectiveness and feasibility, and incorporate LRAD harassment into overall mitigation systems.

THE INFLUENCE OF WIND TURBINES AND HABITAT STRUCTURE ON BREEDING PARAMETERS OF THE ORTOLAN (*EMBERIZA HORTULANA*)

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Abstract

The breeding density of the ortolan (*Emberiza hortulana*) has massively decreased in many parts of Germany since the 1960s. The species is listed on the Red List of endangered species in Germany and in the Appendix 1 of the Council Directive 79/409/EEC on the conservation of wild birds. With the progressive expansion of wind farms also in ortolan habitats there was the need for a study of the effects of wind turbines on the spatial distribution of this species.

This poster shows the results of a study in 5 wind farms with adjacent reference areas in Lower Saxony, Saxony-Anhalt and Brandenburg. During 8 surveys between May and June every ortolan observed was monitored for at least 2-3 hours to get notice of territory size, nest location and mating status. Beside these breeding parameters not only the distance to the next wind turbine was taken into account, but also habitat parameters like agricultural land use, tree species of the next song perch, distance to the next hedge, etc. With several statistical methodologies like correlations, T-tests and multiple logistic regressions, we did not find any significant avoidance effects of males and couples. Nevertheless, the number of pairs in relation to unpaired males increased with growing distance to the next wind turbine. This was due to a surplus of unpaired males in the proximity of wind turbines. The analysis of habitat parameters shows that the distance to the next tree, the tree species (oak) and the land use have significantly more influence on the spatial distribution than the distance to the next wind turbine.

THE ROLE OF WIND TURBINES IN THE CONTEXT OF HABITAT QUALITY – THE CASE OF LAPWING, SKYLARK AND MEADOW PIPIT IN A CULTIVATED RAISED BOG IN NORTHERN GERMANY

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Abstract

Most scientific studies of the displacement effects on breeding birds do not take the habitat quality into account. Therefore they mostly assume that the distribution without wind turbines is more or less uniform. In this way however, it is not possible to separate the effects of wind turbines from the influence of other parameters.
In a 2 year study we compared nest sites and territories of lapwing, meadow pipit and skylark between 2 wind farms (1 in construction within the study time) and a reference site on the basis of areas with the same habitat quality. The habitat quality was calculated by using stepwise multiple logistic regression with presence and absence data of the birds in the reference area. The habitat parameters comprised vegetation and structure parameters, land use, ground colour, distance from houses, etc. The habitat models led to maps representing the occurrence probability of the species with values between 0 (absence) and 1 (presence) in the whole study area. To define areas of good habitat quality a threshold value was calculated which gives the best prediction of presence and absence.
The results show that the density of the species in areas with good habitat quality is equal or even higher in the wind farms than in the reference area. Displacement could only be determined for the lapwing on a small scale (up to 100 m). The before-after comparison of the lapwing breeding density showed a decrease within the overall wind farm area but an increase in the area of good habitat. This emphasizes that assessing the effects of wind turbines without taking the habitat quality into account might lead to wrong conclusions.

PERFORMANCE TEST AND VERIFICATION OF AVIAN RADAR IN THE ADVERSE ENVIRONMENT OF A WIND-POWER PLANT

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Abstract

Spring 2008, a Merlin Avian Radar System (DeTect, Inc.) was placed centrally within the Smøla wind-power plant to continuously record bird activity. The aim of this study was to verify the performance of this avian radar concerning the detection and tracking of small flying objects, such as birds, in the adverse environment of a wind-power plant. Although the performance recorded therefore will be highly site- and system-specific; the methodologies presented will be universal. The main approach taken to radar-performance testing has been to use a controlled test target in live flight tests within the wind-power plant area. To provide a realistic view on the actual performance with real targets, the test target should correspond to the actual targets to be tracked as closely as possible in terms of radar cross section and flight behaviour. A practical solution to these requirements has been to use a remotely controlled model aircraft as the test target. This aircraft was equipped with a GPS receiver, for accurate recording of its position, and its radar cross section (RCS) has been measured in the lab to allow for extrapolation of detection performance to actual bird targets. Because of the highly cluttered environment, in which the clutter has large temporal and spatial variation, the probability of detection (Pd) recorded was generally lower than what would have been achieved in a clear environment. The clutter will reduce the Pd inside the clutter patches in the coverage area. The Pd found indicated a rugged, but generally decreasing function of range, and the range at which the Pd=0.5 for the test aircraft, was about 2350m. This information, together with the aircraft RCS and the theoretical RCS of different bird species, was then used in the radar equation to estimate detection ranges with the horizontal S-band radar for different sized birds (e.g. white-tailed eagle: 1700m range).

RADAR DETECTION AND TURBINE STOPPAGE: REDUCING SOARING BIRD MORTALITY AT WIND FARMS

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Abstract

The increase in the number of wind farms can cause considerable negative impacts on bird populations through collision mortality, displacement and disturbance. Wind farms located on migratory flyways are usually associated with more significant impacts.
The Barão de São João wind farm is composed of 25 turbines (2 MW) and is located in Southwest Portugal, in the most important bird migration flyway. More than 4000 soaring birds (30 species) cross this area annually, mainly during the autumn migration period.
Due to the particular importance of this location, the wind farm's construction approval was conditioned by the implementation of strong mitigation measures. These include a tight surveillance scheme using RADAR and a perimeter of observation points with trained observers, and turbine stoppage when some criteria are met (high migration intensity, occurrence of flocks or presence of highly threatened species). Turbine stoppage is decided by the monitoring team in the area, with basis on the evaluation of potential collision risk. This procedure is implemented annually from August 15th until November 30th.
In 2010, the first year in which these procedures were fully adopted, wind turbines were stopped in 59 occasions, mainly due to the approach of large flocks of griffon vultures, or of highly threatened species such as black stork, cinereous vulture and Spanish imperial eagle.
The use of the RADAR allowed an early detection of approaching birds, while the perimeter of observers provided us with an informed decision about the stoppage of the turbines. This resulted in the absence of mortality, which does not occur in neighbouring wind farms where these mitigation measures are not applied and collisions are frequently detected. The adopted procedures are especially important for vultures, storks and large eagles which do not seem to avoid turbines as efficiently as some of the smaller raptor species.

SHIP-BASED SEABIRD COUNTS AS A BASE FOR MONITORING SEABIRD DISPLACEMENT EFFECTS BY OFFSHORE WIND TURBINES

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Abstract

Currently, two offshore wind farms are being built in the Belgian part of the North Sea. To investigate displacement effect on seabirds, a monitoring research was started in 2005, three years before the first turbines were in place. We delineated reference areas for the two future impact zones, based on comparability in numbers and seasonality of seabirds occurring. From 2005 on, we performed monthly seabird counts along fixed monitoring routes, conform the international ESAS-standard. This BACI set-up should allow us to draw well-founded conclusions on possible changes in seabird occurrence at the impact sites.
For statistical analysis of the resulting data, we describe seabird occurrence making use of several types of models, such as generalised linear and conditional models (in which the effect of time of year is modelled as a sine curve) as well as generalised additive models (time of year included as a spline function). Randomizing the data according to the selected models, and simulating a certain decrease in seabird numbers due to turbine presence, allows us to predict the power of our monitoring set-up. Preliminary results based on a quasi-poison generalised linear model show that for most seabird species, the power is by far insufficient. Only for Common guillemot, the results are acceptable, with a power of more than 80% after five years of monitoring in a 50% decrease scenario. Currently, we are developing scripts to calculate the powers resulting from other models. Finally, we aim to extract the model with the highest predictive value and power.

IDENTIFYING FALSE ALARMS AND BIRD TRACKS IN A FULL SCALE RADAR TRACKS DATABASE USING CLUSTERING ALGORITHMS AND SQL SERVER 2008 ANALYSIS SERVICES

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Abstract

This study is a part of the BirdWind-project initiated by NINA in 2006. All data from the avian radar system from April 2008 has been processed and stored in a SQL Server 2008 database. However, this database contains both bird tracks and false alarms. Due to the huge number of tracks, it is impossible to separate the two manually. Random subsets were generated, and for each track a summary was calculated giving the average and variation in speed, acceleration, target size and shape, reflectivity and tortuousity (i.e. measure for the 'twistedness' of a track). To help us identify false alarms, we included actual weather data like wind and precipitation, since we suspected more false alarms during bad weather conditions. For each track we also calculated a 'clutter ratio', which indicates how many track points were inside areas with much turbine interference. We then used data-mining techniques (Microsoft Clustering Algorithm) on the database server to build different data-mining models. The clustering technique assigns each tracks to a certain cluster based on its signature. The advantages of processing the data on a powerful quad-core processor server are obvious compared to using other data mining tools on a standard workstation, which would take a very long time to build complex data mining models out of 800.000 tracks. These models were correlated with the randomly generated subsets to identify patterns in the different clutters as either false alarm or bird tracks. Since the start of the project, about 2.000 bird track segments have been ground-truthed manually at the wind-power plant. These tracks help us classify the tracks in the different data mining clusters. With these techniques we hope to implement an algorithm which gives a good indication whether a radar track signified a false alarm, a bird track or even a sea eagle.

THE MARINE ENVIRONMENTAL MONITORING PLAN (MEMP) FOR SCOTLAND'S FIRST OFFSHORE WIND FARM: ROBIN RIGG, SOLWAY FIRTH, SCOTLAND.

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Abstract

This paper presents the initial results of a Marine Environmental Monitoring Plan (MEMP) designed prior to construction for the Robin Rigg Offshore Wind Farm to further understand the potential ecological impacts of Scotland's first operational offshore wind farm on ornithology, marine mammals, benthic communities and natural fish populations.
The purpose of the MEMP for the Robin Rigg offshore wind farm (a 60 turbine, 180MW site in the Solway Firth, Scotland) is to assess potential or previously perceived ecological impacts from offshore wind development between the baseline (pre-construction), construction and operational (post-construction) phases of development. The MEMP design process was undertaken in 2004, prior too much of the recent COWRIE guidance work being undertaken for offshore wind farms in the UK.
The MEMP was constructed by regulators, statutory nature conservation advisors, Non-governmental Organisations (NGO's) and the developer and consultants to comply with condition 6.4 of Section 36 Consent Condition, of the Electricity Act and states:
"The remit of the Monitoring Programme will be to allow changes to the physical and ecological environment caused by the construction and operation of the wind farm to be recorded principally in areas where there is some uncertainty in the effects of the wind farm on the receiving environment, where those effects are potentially damaging. The monitoring programme should be designed so that if potentially adverse significant impacts are predicted which can be reasonably attributed to the wind farm, mitigation measures can be adopted in time to avoid irreversible significant impacts"
The MEMP was implemented with the aim that it should be sufficiently robust to detect and/or predict direct and indirect adverse impacts, likely to have a significant effect on the marine environment, arising from pre-construction, construction, operation and decommissioning.
This paper at the Conference on Wind energy and Wildlife impacts (May 2-5 2011, Trondheim, Norway) will identify the areas through which the MEMP approach in Scotland has built understanding for the ecological taxa of concern (birds, marine mammals, benthic communities and natural Fish populations). It will discuss the initial findings between baseline and construction phases and identify any lessons learned from both the process of guiding the MEMP, practicalities through construction/operation and the technical biological data collected as part of the planning requirements.

OFFSHORE WIND FARMS IN THE BALTIC SEA: ESTIMATING CUMULATIVE COLLISION RATES ON A POPULATION LEVEL

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Abstract

In the North and Baltic Seas numerous offshore wind farms will be operated in the near future. Millions of migrating birds (mainly passerines) have to cross the region during their migration from and to Scandinavia. Especially nocturnal migrants are at risk from collisions with turbines. While collision rates at single wind farms are unlikely to have effects at a populations scale, the numbers of victims accumulated across thousands of turbines may have. These effects are beyond the scope of current EIA studies at the wind farm or national level. Using a simple collision model (Band *et al.* 2005) we demonstrate the possible range of variation in cumulative numbers of collisions at 19 wind farms operated or planned in the Southwestern part of the Baltic Sea by applying a range of avoidance and attraction factors. Collision rates varied with wind scenarios and especially bird behaviour. Assuming different degrees of attraction at lighted wind farms in 5 to 10% of migration nights, 0.1 to 1.1% of the autumn population in the case of the robin *Erithacus rubecula* would be affected. Total collision rates of all passerines would range between 100 and 1,000 birds per turbine and year. The behaviour of migrating birds in relation to offshore wind farms at night is insufficiently known and further research is required to verify models and assumptions. The knowledge about additional mortality caused by offshore wind farms is essential in species specific population modelling. Supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety by grant FKZ 0329948 to IfAÖ GmbH, Neu Broderstorf.

MARINE MAMMAL MONITORING; MAKING IT COUNT

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Abstract

Marine mammals are challenging animals to survey. Many populations are wide-ranging, extending across national and international boundaries. Collaborative conservation and management makes sense in the case of such marine species; and these approaches also have merit for baseline and impact monitoring studies that will be undertaken by marine renewable energy Developers to satisfy licensing and consenting requirements under the Habitats Directive and Environmental Impact Assessment Regulations. Collaborative monitoring surveys could also have financial benefits, as demands on resources will be fewer. The scale of Round 3 offshore wind developments and predicted spatial extent of some impacts is such that interactions between adjacent sites and cumulative effects on marine mammals are probable. Moreover, interpreting changes in distribution and abundance of marine mammals in localised areas is difficult as other environmental factors are strong determinants of their distribution. Large-scale data from other sources can help put small-scale survey data into context and whilst such datasets exist, their suitability may be restricted by their limited temporal coverage; often having been collected at intervals of several years. We propose a new approach to Developer-led surveys, where multiple sites are surveyed as part of larger-scale, coordinated programs. While population level monitoring is the responsibility of Regulators as part of the 6-yearly assessment of Favourable Conservation Status; combined multi-site data from Developers could play a more meaningful role in population level assessment and present less of a risk in interpreting small-scale changes in the vicinity of the development. Large scale surveys could also better monitor cumulative impacts of developments. Some impacts (e.g. noise from pile driving at offshore wind developments), have the potential to be far ranging and the overlap of such impacts from concurrent installations at adjacent sites make coordinated, multi-developer surveys advantageous. Cost benefit analysis of simulated cetacean surveys in the Round 3 sites of the North Sea show potential savings up to 25% of the costs of independent site survey, depending on the survey methods chosen (SMRU Ltd, 2010). There is also great potential for sharing platforms to collect different datasets and for multiple taxa; however, methodologies are distinct and we would not, for example, recommend using the same method to survey for seabirds and cetaceans. Collaborative surveying will not only reduce the costs and risks to individual developers but it will also provide Regulators with results that are scientifically more robust.

SUPER HIGH DEFINITION VIDEO SURVEYS FOR BIRDS AND CETACEANS IN OFFSHORE WINDFARM AREAS AROUND THE UK

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Abstract

HiDef have been continually developing a video aerial survey system since 2007. Improvements to aircraft, camera and mounting and survey design have meant that today HiDef can deliver 1cm ground resolution from a super HD camera mounted on an aircraft flying at 610m. After several trials this survey system is currently being used to undertake surveys for birds and marine mammals off the UK coast for clients including wind farm developers and statutory regulators.

The methodology used follows best practice as set out in the guidelines for digital aerial surveys (Thaxter & Burton 2009) and has exceeded these through further recent developments. The survey aircraft flies at 610m altitude with a super high definition camera mount (equivalent to a 100 megapixel stills camera) with an array of sensors recording strip transects covering 10% of the marine areas of interest. Survey tapes are then reviewed and experienced ornithologists at WWT Consulting are used to identify individual records which are then assigned geographical locations.

Survey coverage to date has included several offshore wind farm development areas including both winter and summer surveys of the 8,660 km2 Dogger Bank and the 950 km2 Atlantic Array Round 3 wind farm development zones in the North Sea and Bristol Channel, respectively.

HiDef are continually improving the quality of their video aerial survey service. Though the recommended ground resolution of digital surveys for wind farm ecological assessments is 5cm, HiDef is currently using 3cm as a minimum, with 2cm being used more often and 1cm being commissioned in some areas. Data collected are being analysed to investigate any improvements to camera configuration or survey design to improve mapping of bird and marine mammal species distributions and estimates of abundance. This will have importance in increasing the power to detect changes in populations associated with wind farm development areas.

WATERBIRD HABITATS AND MARINE INFRASTRUCTURES – PICKING THE RIGHT TOOL FOR THE SPECIFIC QUESTION

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Abstract

Marine wind farms, similarly to other large infrastructures in marine environment, interact with wildlife by changing habitats and causing barrier effects. We studied potential effects of a large infrastructure project (fixed link across Fehmarnbelt) on waterbirds wintering in the southern Baltic Sea. Specifically, we assessed potential impacts of habitat loss, reduction in food resources and barrier effect.

We developed and applied a series of new technological methods for studying wildlife and understanding impacts of human activities. By developing this toolbox a lot of questions of applied ecology could be tackled efficiently by using proper tools to answer appropriate questions.

Species-specific waterbird abundance and habitat use were assessed by applying spatial modelling. Aerial and ship-based surveys provided input data on birds, which have been coupled with static and dynamic environmental variables describing geophysical and biological environment, as well as disturbance effects. We fitted Generalized Additive Models to describe interactions of each species with the environment. These models were further used to predict waterbird numbers and distributions given anticipated changes caused by the infrastructure project.

Possible impacts of reduction in food resources we assessed on the most numerous sea duck species, the Common Eider, by applying individual-based modelling. Individual based models relate individual bird behaviours such as feeding activity and food intake rate to environmental factors and allow assessing the factors which constrain species fitness. Individual based modelling allowed evaluation of habitat carrying capacity and making predictions whether reduction in food resources would result in negative effects on bird fitness.

Finally, we used telemetry tools to assess wintering bird behaviour and movements in the impact area, and determine origin and long-distance migrations of the study species. VHF-radio and GPS telemetry of sea ducks provided information on fine-scale movements and foraging activities across habitats during bird wintering season. Satellite telemetry provided additional information about bird local movements and habitat use. It also allowed considering studied species in the context of regional populations through identification of their places of origin, migration routes during the annual cycle, within- and between seasonal site fidelities.

Exhibitors and sponsors

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GP WIND is a project which facilitates deployment of wind energy across Europe and achievement of 2020 targets for renewable energy generation. The project aims to increase the consenting rate and to reduce the processing period for on- and offshore wind projects which are sensitive to environmental and community concerns. GP WIND is supported by the Intelligent Energy Europe program.

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Mester Grønn AS offers fresh flowers and plants through a self service concept. Mester Grønn AS has more than 1,000 employees and nearly 100 stores all over Norway. Mester Grønn has membership of the Ethical Trading Initiative (ETI), sells Fairtrade roses and the company goal is that all their products will be manufactured in accordance with ethical, human, environmental and international standards.

robin

Robin is an independent European company that owns the rights to all TNO bird radar intellectual property, hardware and software. This means we have unique access to the world's most advanced bird radar technology – purpose-designed for tracking and identifying birds since the 1970s. Wind farm operators use Robin bird detection systems both for environmental assessments and during operation.

Sponsors

Statkraft
PURE ENERGY

Statkraft is Europe's leader in renewable energy. The group develops and generates hydropower, wind power, gas power and district heating, and is a major player on the European energy exchanges. Statkraft has more than 3 200 employees in more than 20 countries.

The Research Council of Norway

The Research Council is the chief allocating agency for research funding in Norway and provides key research-policy input to the Government. Through its efforts as an advisory body on research strategy issues, a research funding agency and initiator of meeting places and networks, the Research Council seeks to meet and constantly refine the objectives for Norwegian research policy.

EnergyNorway

Energy Norway is a non-profit industry organization representing about 270 companies involved in the production, distribution and trading of electricity in Norway. Energy Norway's members each year produce nearly 130 TWh, which is some 99 per cent of all power production in Norway. The members of Energy Norway have some 15 000 employees.

Norwegian Water Resources and Energy Directorate
NVE

The Norwegian Water Resources and Energy Directorate (NVE) is a directorate under the Ministry of Petroleum and Energy. NVEs mandate is to ensure an integrated and environmentally sound management of the country's water resources including flood contingency planning, maintaining national power supplies, and promoting efficient energy markets and cost-effective energy systems.

NORWEGIAN DIRECTORATE FOR NATURE MANAGEMENT

The Norwegian Directorate for Nature Management (DN) serve as an executive and advisory body for the Ministry of the Environment, and the main areas of responsibility are outdoor recreation and the conservation and sustainable use of biodiversity. DN is responsible for implementing the Government's environmental policy, and for identifying, preventing and dealing with environmental problems.

SØR-TRØNDELAG FYLKESKOMMUNE

Sør-Trøndelag County Authority is responsible for tasks that are too large or too complex for the municipalities to manage alone. Sør-Trøndelag County Authority develops and promotes the region through local and international partnerships. The Council is responsible for regional planning and has environmental responsibilities. The Council promotes the cultural life of the region.

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